THE ENGINEER

A Seven-Day Journal

Discussions on Metal Economics

A GENERAL discussion on the subject of metal economics has been organised by the Institute of Metals and will be held at the Park Lane Hotel, London, W.1, on Wednesday, October 17th, under the chairmanship of Professor A. J. Murphy. The discussion has been arranged for two sessions, the first dealing with primary resources of ferrous and non-ferrous metals, and the second with scrap reclamation, secondary metals and substitute metals. It is anticipated that a number of well-known authorities on the subjects will speak in the discussions. In the first session the following papers will be presented: "The World Supply of Non-ferrous Metals, Including the Light Metals," by Mr. R. Lewis Stubbs; "Metals as Natural Resources," by Professor S. Zuckerman, and "Iron-ore: World Demand and Resources," by Dr. T. P. Colclough. During the second session papers will be read on the conservation of metals by Mr. C. A. Bristow, Mr. J. Sidery and Dr. H. Sutton; economy by standardisation of alloys and of the method of reclamation of scrap metals by Mr. C. Dinsdale; the influence of specifications on productivity and the economic utilisation of ferrous and non-ferrous metals by Mr. F. Hudson; secondary heavy metals by E. H. Jones, and secondary aluminium and magnesium by Colonel W. C. Devereux. The meetings are due to start at 10 a.m. and will conclude at 5 p.m., and a booklet giving some details of the matters to be dealt with in the papers has been published by the Institute of Metals.

Chemical Research Laboratory

ON Wednesday of last week, at the invitation of the director, we paid a visit of inspection to the Chemical Research Laboratory of the Department of Scientific and Industrial Research. The work is divided into several main sections, such as the corrosion of metals, the inorganic and the radio chemical sections, and the high polymers and the microbiology sections. Among many interesting exhibits and demonstrations was the electrochemical study of anaerobic microbiological corrosion, which illustrated the need to protect metals underground and the value of cathodic protection methods. An interesting method of stripping surface films from metals by use of a surface reinforcing resin and iodine in anhydrous methyl alcohol was noted, as was also a display of corrosion inhibitors. Graphs gave the results of experimental work, using electrochemical methods for the study of the behaviour of protective coatings on metals. For this work the recording of electrical capacitance changes, using alternating current at 1000 c/s indicated the water uptake and the time taken to break down of paint films. Other graphs showed the water uptake of paint films as a function of the osmotic pressure. The electron diffraction camera was being used for identifying the material of oxide films and a new multi-source excitation unit was noted, which uses a.c. or d.c. and has a wide range of control. The systematic variations in polymer structure was illustrated and the determination of the molecular weights of polymers in solution by osmotic pressure measurements. In the radiochemical group the use of ion-exchange resins in separation processes was demonstrated by an exhibit which consisted of a small-scale multi-column adsorption system, in which copper was removed from a copper containing liquid. A method consisting of burning a sample of liquid in air over a vanadium pentoxide catalyst was shown as the means of analysing the sulphur content in organic liquids, and in another laboratory the properties and potential value to industry of the metallic elements, germanium and gallium, were illustrated. Of considerable interest was the investigation, in association with the British Shipbuilding Research Association, into the corrosion of steel tubes in Scotch marine boilers, and an example of a wrought iron tube, which was in good condition after twenty-seven years of service, was shown alongside a steel tube, which was corroded away after being in use for five years, and so served to illustrate the need for such research.

Productivity Team Report on the Brass Foundry Industry

THE report of the productivity team on the brass foundry has now been published by the Anglo-American Council on Productivity. This report points out that the American brass-foundry industry is not so up to date and highly mechanised as many people might think. Actually the industry in the United States is similar to that in Great Britain, being made up of a large number of relatively small foundries. The team considers that on the technical side Britain is ahead of American standards, but the output per man-hour is higher in plants in the United States than in foundries of similar type and size in this country. Several reasons are given for this greater output and, as has been suggested in the reports of other productivity teams, the chief reason is stated to be the greater incentive to earn and the will to work hard and effectively. The second reason given is the maximum use made of mechanised aids incorporated in a lay-out of simple but efficient design in even the smallest American jobbing foundries. Other reasons include the effective use of standardisation and simplification; the use of core boxes and patterns of high quality and accuracy; the willingness shown to try out new methods and techniques; and attention given to planning, welfare and safety. The team recommends that in this country the Government should endeavour to inspire anew the spirit of adventure in both management and worker, promote a real team spirit and provide tangible incentives to all to earn more and produce more. Industry, it is stated, should promote greater incentives to earn amongst all levels of employees, and greater attention should be given by management to plant lay-out, production planning, the use of mechanical aids, standardisation and simplification. The final conclusion is that the British worker should make up his mind whether he wants security and leisure or a better standard of living, which can only be obtained by effective work.

Derailment of the Liverpool-Euston Express

AT 11 a.m. on the morning of Friday last, when the 8.20 express from Liverpool to Euston was travelling at high speed, it became derailed at Weedon and the engine and several coaches crashed down a shallow embankment, just after passing through Stowe Hill Tunnel. Reports state that the actual derailment started some 600 yards before the train entered the 500-yard long tunnel and the track in the tunnel was torn up. About 400 yards south of the tunnel the engine finally left the track and dragged some of the coaches down the embankment into a field. Of the 700 passengers on the train eight were killed outright and five died shortly afterwards as a result of their injuries; twenty-six other persons were detained in hospital. The northwards-bound Royal Scot, which was due to pass the scene of the accident, was stopped by prompt action on the part of the railway staff.

Science and the Building Industry

AT the closing session of the Building Research Congress on Thursday, September 20th, Sir Ben Lockspeiser, Secretary of the D.S.I.R., discussed the place of science in the building industry. He spoke of the economic importance of building and remarked that, although considerable progress had been made in the past twenty-five years, there was still far too much ugliness and drabness in houses and factories. In other parts of the world the social problems arising from bad housing had reached proportions that were threatening not only the political and economic wellbeing of those parts, but ours as well. He noted that the period during which scientific research had been applied to building was not substantially more than thirty years, during which improvements in the common materials of building and in components, and a further understanding of their use had influenced design, construction and maintenance. Much had been added to the store of knowledge at the disposal of industry, but, Sir Ben continued, there was an uneasy feeling that building, which for so long had nothing to learn from science and engineering, was now, to one degree or another, unwilling or unable to learn. Sir Ben went on to say that one of the papers before the Congress indicated the beginnings of a very welcome change of outlook and practice in the U.S.A., but it was not to our credit that we were now getting accustomed to looking to the U.S.A. to make significant technological advances. About half a million pounds was spent each year on the Building Research Station in this country, Sir Ben said, for the benefit of the community and the industry, the value of whose output was of the order of £1300 million. There was no doubt that this expenditure brought a good return, but he thought that the return might be many times more.

Progress of Harlow New Town

THE Parliamentary Secretary of the Ministry of Local Government and Planning, Mr. Lindgren, formally opened the industrial estate at Harlow New Town on Monday, September 24th. Eight units of sectional factories, two standard factories, and one special-purpose factory have now been built in the town, and the industrial undertakings which are already at work in these factories include light engineering, medical appliance and scientific instrument works. Four other standard factories and five units of sectional factories are at present under construction. A 6-acre site is being levelled for a glass bottle manufacturing company, which will build its own factory. In the near future work will begin on two standard factories, four units of sectional factories and two other factories to be built by their owners. All the firms which have taken, or are taking, sites in Harlow come from London in accordance with the plan for the decentralisation of industry and population. The various undertakings are expected to provide industrial employment for 1100 people in the course of the next two years, and housing progress in Harlow is keeping pace with factory construction. Nearly 1000 homes are now being built, and contracts have been let for a further 1000. Some 400 homes are already occupied, and although the present house-building programme is for some 1000 homes a year, it is hoped to increase this figure before long to 1500 a year.

The Grand Coulee Pumping Plant, Coulee Dam, Washington

No. II—(*Continued from page 358, September 21st*)

The Motors

At the present time contracts have been issued for six motors, one for each of the first six pumps. The first two are being furnished and installed by the General Electric Company of Schenectady, New York, and the next four are being supplied by the Westinghouse Electric Corporation of Pittsburgh. The motors, Fig. 10, are 65,000 h.p., 13·6kV, three-phase, 60 c/s, synchronous machines, similar in design to hydro-electric generators of equal capacity. Their rotors have squirrel-cage windings to permit starting them as induction motors. Because of the large size of the motors, careful consideration had to be given to the starting procedure. Starting on 60 c/s supply from the power system at reduced voltage would have taken excessively high current and caused high stresses in the winding of both generators and motors. This method was therefore dropped in favour of (1) the synchronous method, and (2) the induction-motor method of starting. Normally the synchronous method will be used. With this method one or two motors will be connected directly to a single generator at standstill. The generator and motor field rheostats will be set to obtain the best starting conditions. Both generator and motor field coils are excited simultaneously. When the turbine gates are opened, the generator and pump motor or motors are accelerated by manual regulation of the turbine gates. Then the turbine is placed on governor control to maintain a 60 c/s speed. This method of starting the motors develops the starting and accelerating torques required by the pumps.

When using the induction-motor starting method, the generator, without excitation, is started and brought to about 65 per cent of synchronous speed for starting one motor and 70 per cent for starting two motors. The generator and the motor or motors are then tied together directly. The generator field coils are excited, causing the motor or motors to accelerate. In the meantime, the turbine gates have been closed. As the motors accelerate and the generator slows down, they approach the same speed. When their speeds are close enough to synchronise the motor field coils are excited and the machines pull into step. The turbine gates are then opened to bring the units up to speed, when the turbine is placed under governor control.

Because of the long discharge pipes, which vary in length from 900ft to 665ft, the water flow will reverse through the pumps during normal shut-down periods. To take care of these conditions, the motors have been designed for reverse rotation and for stresses due to a runaway speed of 295 r.p.m. A thrust bearing above each motor supports the weight of the rotor and the unbalanced hydraulic thrust, totalling over 300,000 lb. These bearings are equipped to supply a positive oil film between their surfaces before starting, to keep the starting torque to a minimum.

Each motor is provided with air-operated brakes, which can be used also as hydraulic jacks to lift the rotating parts of motor and pump for the purpose of removing or adjusting the thrust bearing. The brakes are designed to bring the rotating parts to rest, from 100 r.p.m., within five minutes. The control system automatically prevents the application of the brakes above half normal motor speed. The motors, like the generators in the power station, are cooled with water from the reservoir. Air is forced through openings in the shell of the stator into the air chamber surrounding it; due to the fan action of the rotor, the air is cooled by the eight heat exchangers placed over the openings. Water at a maximum temperature of 20 deg. Cent. keeps the circulating air below 40 deg. Cent. The oil in the thrust bearing reservoir is cooled by water circulating in a copper coil submerged in it.

On the control board for each unit there is a selector switch, which enables the operator to take temperature readings at two points in the bearing metal of the thrust bearing, at one point in each guide bearing, and at ten points in the stator windings. Two other resistance temperature devices in the stator windings are connected to thermal protective relays. Mercury thermometers show the temperatures of the oil in the bearing reservoirs and the cooling water. The rotor, which has a diameter of 18ft 9½in, contains approximately 2766 sheets of rim punchings. Mounted about the perimeter are thirty-six coils, each weighing 3600 lb.

Fig. 10—Assembly of Stator of Pump Motor

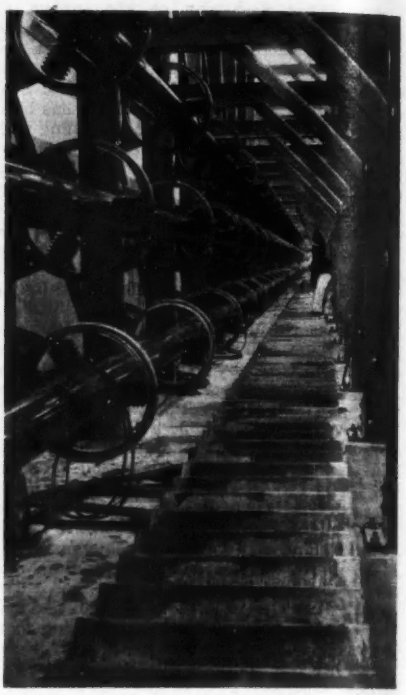


Fig. 11—Bus Bars Connecting Pump Motors to Generators

The vertical height of the rotor is 4ft 11½in. The stator is 24ft 2in in diameter and has a height of 9ft 1in. It is made up of four sections, each weighing approximately 52,000 lb. The stator comprises 300 coils, approximately 6ft long and weighing 180 lb each. Thirty-two of the stator coils were installed at the pumping plant; the remainder at the works of the General Electric Company. The thirty-two coils are situated at and adjacent to the junctures of the four quarter-arc sections of the stator.

The busbars, shown in Fig. 11, which connect the pump motors to the generators at Grand Coulee power station, are hollow copper tubes, approximately 7½in diameter. The busbars, which connect "L-1" generator in the left power station with motor "P-1" in the pumping plant, are approximately 725ft long. A concrete and aluminium structure, known as the "bus runway," houses the busbars running from the generator at the foot of the dam, to the pumping plant upstream behind the dam. The bus runway is 389ft long. The busbars are enclosed and insulated within a cylindrical aluminium housing, which has an inside diameter of 21in.

Inlet and Discharge Works

The pump inlets are controlled by 13ft × 20ft reverse-flow roller gates, travelling on stainless steel endless-chain rollers, and are operated by a hydraulic mechanism. In the closed position they can seal on either side, depending on the direction in which pressure is exerted. In this manner they

permit unwatering of the inlet pipe and pump casing below lake level or, if the discharge pipe is full, they prevent reversal of flow, of such magnitude as to damage the pumps or pipes in case of power failure or other sudden stoppages. The operation of the gates is controlled manually. The gates are so large that their assembly has to be completed at the pumping plant site. They are lowered into position by the 75-ton gantry crane, which has been erected on the wing dam.

The suction tube is 14ft in diameter and 60ft long. Hemispherical steel bulkheads were installed to seal the tube at the discharge end, inside the wing dam, at the time the wing dam was being built. The suction elbow is 14ft in diameter at the lower end and tapers to 7ft 6in in diameter at the upper end. It is fabricated in five sections and assembled and welded in the field. The most severe suction conditions occur at low reservoir capacity, when water surface at the intake is at elevation 1208. Hence, the centre-line of the pumps has been placed at elevation 1203, so that a positive suction head of at least 5ft exists on the pumps. This is believed to be sufficient to prevent cavitation. Since irrigation requires that practically all water be pumped during flood-water periods, the possibilities of operating with only a 5ft positive suction head are not likely to occur. The twelve discharge pipes vary in length from 900ft to 665ft. They have an inside diameter of 12ft. Twelve tunnels, from 411ft to 466ft in length, carry the pipes up through the canyon wall behind the pumping plant. Upon emerging from the tunnels, the pipes continue on concrete piers as shown in Fig. 12 for distances of 145ft to 375ft before discharging into the headworks of the feeder canal.

The feeder canal, Fig. 13, is 1·8 miles long. It runs south-westerly from the pumping plant discharge pipes to the North Coulee dam and empties into the equalising reservoir. Its capacity is 16,000 cusecs. It is 25ft deep, 125ft wide at the top and 50ft wide at the bottom. There are three check gates in the canal at the North dam, to prevent water from backing into the feeder canal once the equalising reservoir has been filled. The twelve discharge pipes have siphon-breakers, installed at the headworks, to prevent water drainage from the canal back through the pumps, in case of a shut-down or a breakdown.

Two earth-fill dams, 27 miles apart, seal a portion of the dried ice age channel of the Columbia River to form the equalising reservoir for the Columbia Basin project. The South dam, near Coulee City, is nearly 10,000ft long, with a maximum width of 450ft at its base. The maximum height is 80ft above natural ground surface and 120ft above lowest bedrock. U.S. Highway No. 2, to Wenatchee west, and Spokane east, is situated along its crest. The North dam, near the town of Grand Coulee, is approximately 1400ft long and 145ft high from lowest foundation rock. It is approximately 2 miles from Grand Coulee dam. The feeder canal empties into the equalising reservoir at the north side of the North dam.

Pump-House Construction

Interesting details relating to the construction of the pump-house have been given by the late S. J. Bolman, a civil engineer on the staff of the Bureau of Reclamation at Coulee Dam.* As mentioned previously, the discharge pipe tunnels were excavated under a pre-war contract. In general, the horizontal sections were drilled with a jumbo mounting multiple drills and the blasted material was removed with shovels and bulldozers. Various schemes were attempted in the "raises" to facilitate the simultaneous use of a number of stopes and to provide separate manways and muck chutes to reduce delays in cleaning up and reinstalling equipment after each blast. All material was, of course, allowed to fall to the bottom of the raise and was then removed from there. The section of each pipe ahead of the lower bend, including the bend, was installed from the lower end of the tunnel. The remainder was lowered through the tunnel from the top in sections. The sections were welded after being placed and braced in position and all welds were inspected by means of radiography subsequently. The pipe within the tunnel was then embedded in concrete and the interior of the entire pipe coated with coal-tar enamel. The exterior of exposed portions was painted with aluminium paint.

The construction of the pump-house presented problems differing from conventional above-ground construction, since the major part of the building is situated in a cavity 140ft deep, 650ft long, and increasing in width from 26ft at the bottom to 157ft at the top. This cavity was formed in 1938 and 1939 by blasting out the granite cliff southward from the west abutment of the main power dam to form a level, rectangular bench 140ft below the top of the dam. The pumping plant dam, constructed on the outer edge of this bench, served to withhold the lake water from the cavity. This dam, Fig. 14, was constructed integrally with and at an angle of 67 deg. to the east-west main dam. The north wall of the cavity was thus formed by the left abutment of Grand Coulee dam. In this cavity, bounded by excavated cliffs on two sides and by the dams on two sides, working space was limited and there was no room for the storage of construction materials. All materials for the major part of the structure had to be lowered into place. The width of the cavity at the top necessitated the use of long jib cranes. Operating on tracks on top of the pumping plant dam, two gantry mounted, self-propelled, revolving cranes met this requirement. Each crane had a

FIG. 12—DISCHARGE PIPES

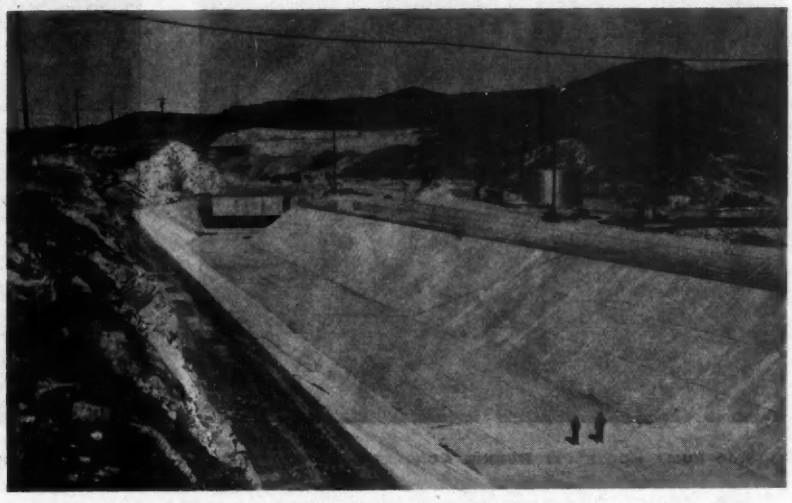


FIG. 13—FEEDER CANAL AND HEADWORKS

* *Civil Engineering*, June, 1951, page 34.

CONSTRUCTION OF THE PUMP HOUSE AT GRAND COULEE DAM

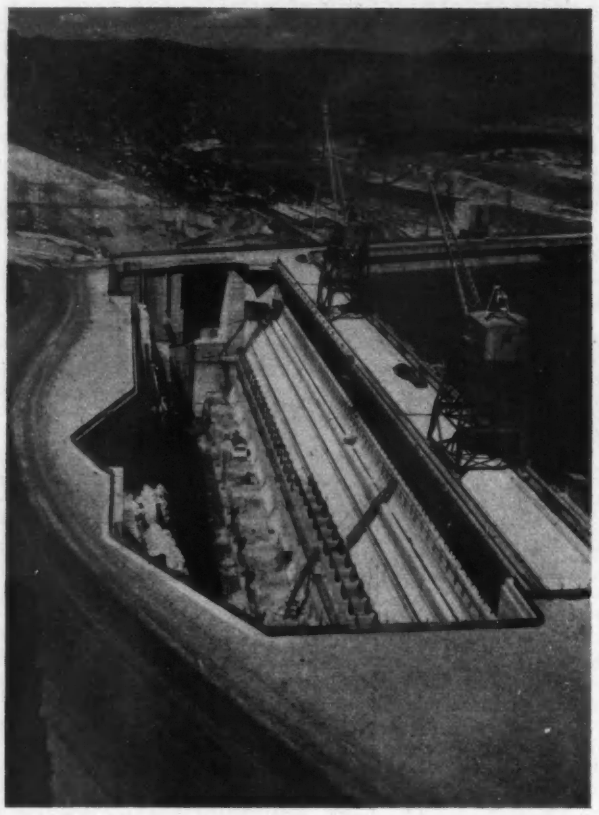


FIG. 14—PUMPING PLANT DAM WITH GANTRY CRANES

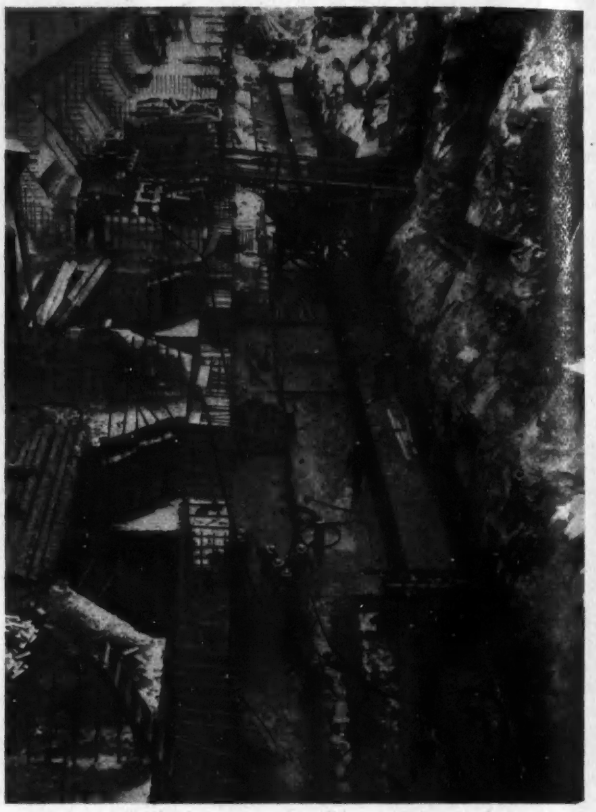


FIG. 15—CONSTRUCTION IN PUMP HOUSE PIT

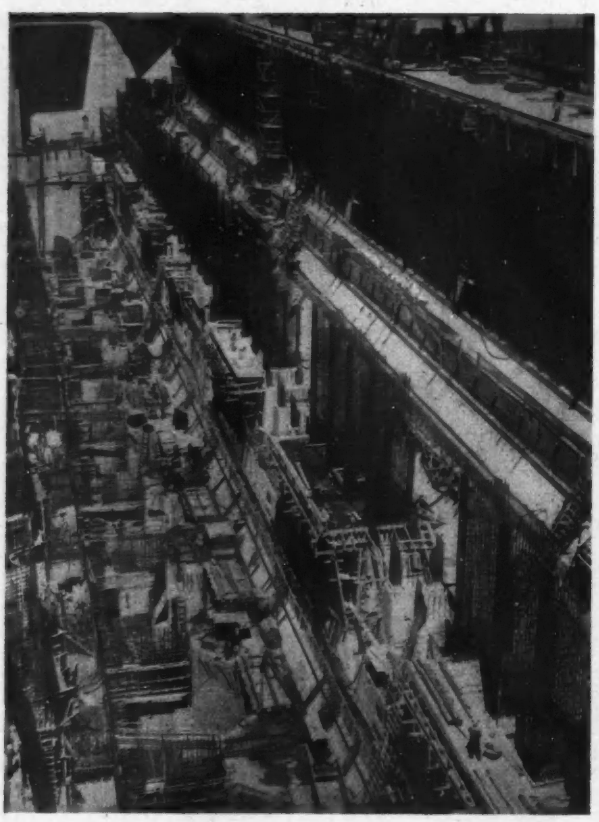


FIG. 16—PUMP HOUSE PIT DURING CONCRETING OPERATIONS

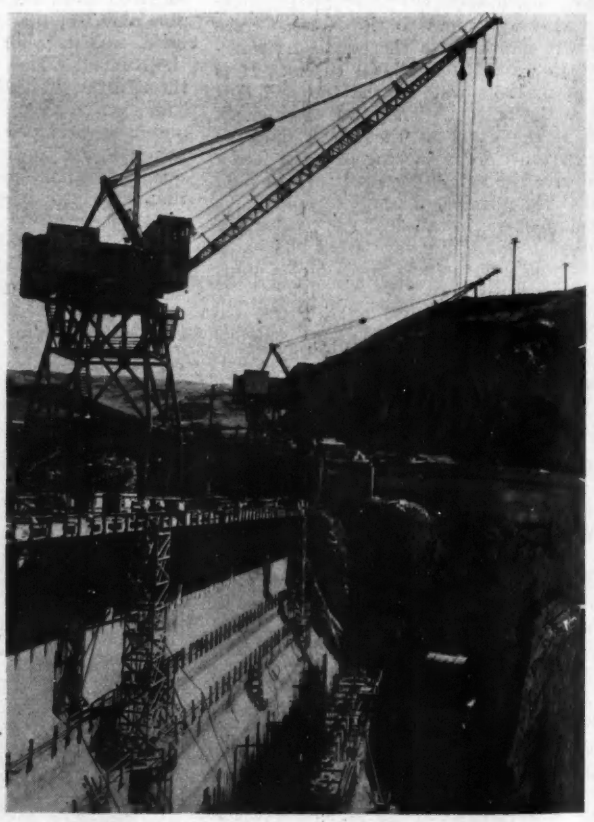


FIG. 17—INSTALLATION OF DISCHARGE PIPE SECTIONS

rated capacity of 38 tons at a 48ft radius. A fixed still-leg derrick was erected on the upper ground level at the south end of the structure for lowering concrete and materials into the south units and for handling moulds and timber in the adjacent panel yard. A crawler crane, which was operated at the upper bench level on the rock cliff on the west side, handled a part of the close-range work on that side of the building.

The emplacement of concrete in the structure called for careful planning to avoid interference with other construction operations, such as placing and removing of moulds, the placing of reinforcing steel and the installation of the 12ft diameter discharge pipes in the lower portals of the discharge-pipe tunnels, Fig. 15. The construction procedure adopted by the contractor was to maintain alternate high and low units, the even-numbered units being constructed considerably in advance of the odd units. This was necessary to facilitate the emplacement of tall prefabricated reinforcing units in the wall columns without interference with the shuttering in adjoining units, as the total thickness of the required shuttering was greater than the distance between the reinforcing bars in the adjoining units. As the building was designed with expansion joints between the fourteen consecutive adjoining units, each unit was, in a sense, a separate structure. When completed, the structure filled and completely decked over the cavity which existed before the contract was started.

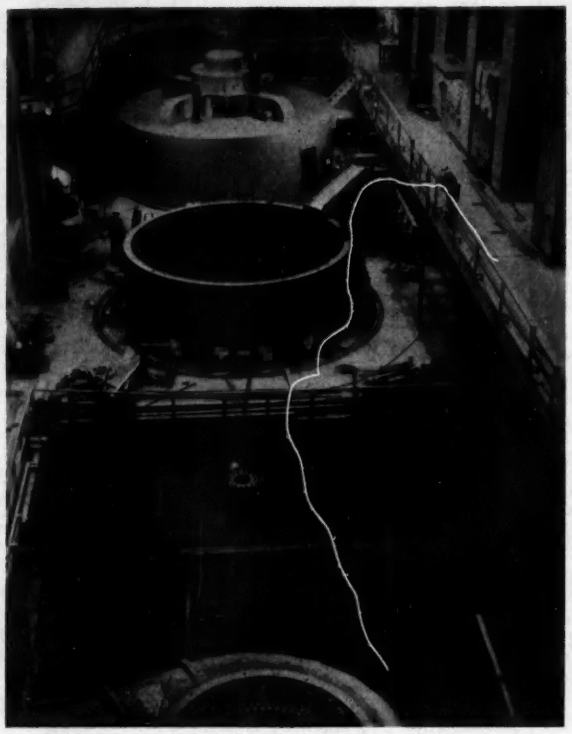


FIG. 18—INSTALLATION OF PUMP MOTORS

The main pump-house (Fig. 16), situated approximately midway between the pumping plant dam and the rock cliff to the west, consists of two heavily reinforced concrete walls 59ft centre to centre, parallel to the pumping plant dam, with columns along the wall spaced at 15ft centres. The lower part of the west wall, for a height of 55ft, was thickened in a westward direction to fill all space between the wall and the excavated rock cliff on the west. A step on the sloping face of the pumping plant dam, 55ft above the bottom of the structure, provided a footing for the east wall. The 616ft long, wedge-shaped opening in the bottom, for a height of 55ft, was divided into units by cross walls running between the sloping face of the pumping plant dam and the west wall. These walls, which are 2ft thick, were placed in pairs, back to back, at 45ft intervals. In this manner pits 43ft in length and 55ft deep were formed, in which the pumps and appurtenances are now being installed. The south end unit, which is 60ft long, contains no pit. Instead, a mass concrete block, 55ft deep, was installed there to serve as a foundation for the erection of the pump motors.

The lower ends of the twelve steel discharge pipes were embedded in the lower, mass-concrete portion of the west wall (Fig. 17). The pipes are level at this point and 32ft above the bottom of the structure. The two main walls, above the 55ft pits, extend 85ft higher, to the top of the dam. There is one reinforced concrete floor at the top level and one 20ft lower. There are no partition walls between units in this part of the structure. The lower room, 58ft in height and 555ft long, serves as the pump motor-room, and the upper is an employees' vehicle-parking gallery. The 60ft erection bay on the south is open to the roof of the storage building.

CONCRETE PLACEMENT

Reinforcing steel was fabricated into column and girder units at an assembly yard approximately 3 miles west of the plant, transported by road to the site and lowered by means of cranes to the structure. A total of approximately 7000 tons of reinforcing steel was used. The shuttering for the underside of the girders was set to line and grade and the heavy fabricated reinforcement steel units were set. The girder side, slab and beam shuttering was then completed and the reinforcement laid and tied in place in the slabs and beams. Prefabricated units of column steel were set in place by crane, the wall steel was placed and plywood shuttering panels were set up around the steel.

Second-stage concrete was placed in the pump pits in two separate operations. The first operation consisted of placing reinforced concrete in six lifts against the west wall, in which no pump parts were embedded. This provided a foundation against which to brace the suction elbow and a level foundation on which piers were placed to support the pump casing. An opening was provided therein for the installation of the suction elbow. The second operation in the placing of the second-stage concrete consisted of placing the pump suction elbow, the pump casing and the discharge section of the pump casing extension, which is connected to the discharge pipe. The installation of the roller gates over the inlets on the lake side of the dam then made it possible to remove the temporary bulkhead at the inside end of the inlet pipe. The pump was connected, before it was embedded, to the inlet pipe from the lake. The suction elbow was lowered in sections, the joints welded and the elbow attached to the inlet by welding. The elbow, thus attached, curves upward for attachment to the under-side of the pump. The surrounding concrete was then placed round the elbow in four lifts. The pump casing and parts were assembled in place on jacks and attached to the suction elbow and to the 12ft discharge pipe projecting through the west wall. Reinforcing steel, conduit, embedded metal and concrete were placed to an additional depth of 16ft in three lifts. The pits were thus backfilled solidly around the pumps and parts to a depth of 37ft 6in, except for small galleries for inspection and access to the inside of the pumps.

The motor foundation consists of an octagonal hollow concrete column resting on the concrete in which the pump is embedded. The octagon of 12·4ft side and with a 17ft diameter hollow centre, provides support, Fig. 18, for the vertical shaft motor and space for the shaft. A reinforced concrete floor, 48ft by 43ft by 5ft 6in thick, was then placed monolithic with the octagon and supported by steps in the surrounding walls and on the dam. Anchor bolts placed vertically in the floor serve to hold the bearing plates of the motor stator.

The construction of the pumping plant involved the placing of 63,800 cubic yards of concrete in the pump building and auxiliary structures and an additional 2060 cubic yards per pump unit for embedding the pumps and the construction of the motor foundations within the pumping plant. Concrete was placed in the lower 55ft of the structure in lifts varying in depth from 5ft 6in to 18ft 6in. The main structure above was poured in lifts varying from 6 ft to 8ft in height. To lower concrete from the top of the dam 2 cubic yard and 4 cubic yard bottom-dump buckets were used. Concrete was delivered by 4 cubic yard "dumperete trucks," from the mixing plant, and dumped into holding hoppers at the top of the dam. The hoppers were discharged into the 2 cubic yard and 4 cubic yard buckets. To deposit concrete in the moulds in walls and other confined places, rubber pipe was used. This pipe was approximately 10in in diameter and 20ft to 30ft long. It was clamped to the bottom of a funnel-shaped hopper, which, in turn, was connected by a quick-change attachment to the bottom of the concrete buckets. The buckets were dumped directly into open pours without using the rubber trunk. A duplex concrete pump was used to deliver concrete for the first operation of the second-stage concrete through an 8in diameter "quick-joint" pipeline. The pump was placed at the north end of the building and the concrete was dumped into chutes leading to the pump below.

For the first ninety days of the contract concrete was produced at the Government-owned plant on the east side of the river downstream from the dam. This plant consisted of a 2 cubic yard tilting mixer with a capacity of about 40 cubic yards per hour. All concrete in the structure placed after this period was mixed at the contractor's plant on the west shore of the reservoir, about three-quarters of a mile south of the pumping plant structure. The plant consisted of two 2 cubic yard non-tilting mixers with an 8 cubic yard receiving hopper. The mixing capacity of the plant was 80 to 90 cubic yards per hour.

The concrete aggregates were obtained from storage piles, which had been processed under a previous contract from raw aggregates obtained from a deposit north-east of the Grand Coulee dam. The sand for the concrete and for sandblasting operations was obtained from a waste sand pile. Cement was pumped a distance of half a mile from the storage silos to the contractor's mixing plant by an air-actuated cement pump. For the concrete in the structures, a 1½in maximum aggregate was generally used, except in thin walls and confined areas. A water-cement ratio of 0·60 was used in concrete unexposed to outside atmospheric conditions and one of 0·53 in exposed areas.

The Grand Coulee pumping plant was designed under the direction of L. N. McClellan, chief engineer of the Bureau of Reclamation. The contractors' operations were supervised initially by A. O. Strandberg, who was succeeded, in February, 1951, by R. H. Madsen.

The Paris Machine Tool Exhibition

No. II—(*Continued from page 367, September 21st*)

AMONGST the many kinds of production milling machines exhibited was the circular table milling automatic for the mass production of small components illustrated on this page (Fig. 6). This machine is one of a series made by Fritz Kopp, Neu-Ulm/Do., Germany, a firm represented in this country by A. C. Wickman, Ltd., of Coventry. It consists of a rigid box-base carrying a rotating work table and having a horizontal spindle milling head on each side. The milling cutter spindles are actuated at infinitely variable feed speeds through a hydraulically operated cam mechanism to move up and down and in and out in respect to the workpiece in the centre. By using the two automatic spindle movements in conjunction with the rotation of the table, a very wide range of machining can be effected.

Workpieces are mounted on fixtures round

FIG. 6—CIRCULAR TABLE MILLING AUTOMATIC

the circumference of the table, and high-speed indexing is employed between the work stations. Loading and unloading of the fixtures is carried out whilst machining is in progress. The table is 550mm in diameter and takes work which increases its diameter up to 800mm. Machines can be supplied with three ranges of six spindle speeds, from 60–800, 250–1400 and 355 to 2000 r.p.m. Twelve rates of table feed from 15mm to 190mm per minute are available, and rapid indexing is carried out at 720mm per minute. It will be appreciated that the machine can be adapted to carry out two milling operations on a single component, or machine two components at the same time, one on each side of the table.

A machine of similar design is made by the firm for copy milling in which case a cam is fitted to the circular table. This cam actuates an arm controlling the hydraulic mechanism of the cutter heads, which, in following the contour of the master, reproduce its profile on the workpiece. The cam follower arm incorporates means of micrometric adjustment through which allowances can be made for initial cutter diameter and compensation for cutter regrinding.

Some notes on the planing machines which were exhibited on the stand of Adolf Waldrich Coburg G.m.b.H., of Coburg, Bavaria, were given in our article dealing with the Hanover Fair in the issue of June 1, 1951. Another machine shown at Paris was the long-thread cutting machine illustrated in Fig. 7, which is a recent addition to the firm's products. This machine uses tungsten carbide cutters to the best advantage to obtain very high production rates. It is made in three types for cutting threads or bars from ½in to 1½in diameter, 1in to 2¾in diameter, and 1½in to 5in diameter. The respective maximum leads at 30 deg. are 1½in, 2¾in and 5in, and at 40 deg. ¾in, 1½in and 3in. The smallest machine is made in four sizes to admit from 1ft 8in to 6ft 8in between centres; the second type of machine in three sizes to take from 3ft 4in to 10ft between centres, and the largest machine in three sizes to take from 6ft 8in to 13ft 4in between centres.

The machine is of very rigid construction with the cutter head slide or saddle carried on wide verticle guideways and having narrow slideways for longitudinal and feed movements. A tool head mounted in the hollow cutting spindle of the machine carries the interchangeable tools of tungsten carbide. This hollow spindle is carried on roller bearings in the cutter head slide, and it can be adjusted on two parallel vertical planes in order that the tool can be set according to the helix angle of the thread. The tool can also be adjusted in the second plane within an angle, determined by the size of the thread, so that the metal is removed in the form of small flat chips.

Work steadies carried on the cutter head slide can be adjusted whilst the machine is operating to support the work immediately in front and behind the head. The depth of the thread cut is set by means of a hand-wheel, and stops on the saddle, and the setting accuracy is stated to be 0·005mm in diameter. The speed at which the saddle is moved along by the lead screw of the machine is set by a chain of pick-off change gears between the work spindle and the lead screw, and an index attachment is used when cutting multiple start threads. A rapid return traverse is used to return the slide to the start position after each cycle. The machine is driven by d.c. motors and the speeds of the work and the cutter spindle can be adjusted over an infinite range.

The firm of Waldrich is represented in this country by Drummond Asquith (Sales), Ltd.

A number of milling machines fitted with three-dimensional copying attachments were exhibited, but a mould copying machine, made by Maschinenfabrik Michael Kämpf K.G., of Frankfurt am Main, Germany, which we illustrate in Fig. 8, is of particular interest. This machine has two tables; one for the master of the mould and the other for the workpiece, and the tracer and cutter heads mounted on the horizontal overarm are connected by a pantograph mechanism, through which the scale of reproduction can be varied.

The vertical pantograph has its centres of rotation secured in precision slides, which are adjustable in slots machined in its arms. The cutter head and tracer move freely in a vertical plane in slides connected to the pantograph members and these slides are free to move under the same control along the overarm ways. The overarm is of very rigid design and is swung on large bearings on the main column of the machine.

The spindle of the cutter head is driven through stepped cone pulleys by a 1 h.p. motor, and a range of speeds from 270 up to 6400 r.p.m. is available. Both the worktable and the tracing table have a

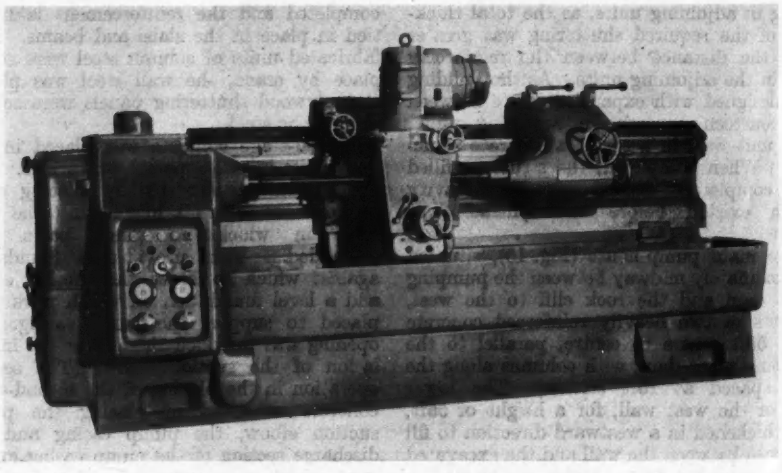


FIG. 7—LONG THREAD CUTTING MACHINE

vertical adjustment of 390mm, and work up to 380mm high can be accommodated. The tracer, which is selected according to the class of work, has a maximum working height of 85mm. Both of the tables are adjustable longitudinally and transversely through handwheels, the respective movements being 185mm and 270mm on the worktable and 240mm and 260mm on the tracing table. It will be appreciated that by using the table transverse and longitudinal movements a number of similar forms

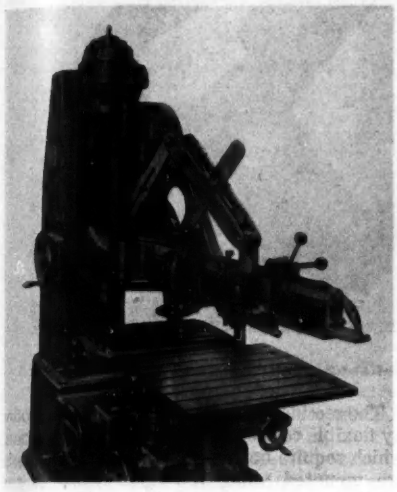


FIG. 8—MOULD COPYING MACHINE

can be sunk in a single workpiece at one setting if multiple moulds are being cut.

In Fig. 9 we illustrate a heavy vertical milling machine fitted with an interesting table, which was exhibited by S.O.M.U.A., 170, Old Victor Hugo, Saint-Ouen-sur-Seine, France. This machine has a 3⅝in diameter spindle driven by a 15 h.p. motor having two speed ranges, giving twenty-one speeds, from 10 to 1000 r.p.m. Through one speed change lever controlling an automatic selector, sixteen spindle speeds, from 32 to 1000 r.p.m. are available and through a second lever a similar number of speeds from 10 to 320 r.p.m. can be obtained. The spindle is carried in taper roller bearings on the head, which is mounted on heavy ways and has a vertical movement of just under 18in.

The table, which has a working surface of about 4ft 5in by 2ft 6in, is fitted with a centrally disposed rotating table of 2ft 6in diameter. All its movements are obtained from a separate 5 h.p. motor at the side of the machine, the travel in the longitudinal direction being 4ft and in the transverse direction 2ft 8in. Twenty-one longitudinal, transverse and rotary table feeds, from ⅛in to 32in per minute, are provided and fine table settings are made by the large handwheels fitted with micrometers.

The wide range of milling machines made by this company are distributed in Great Britain by the Selson Machine Tool Company, Ltd.

From the range of plant it manufactures, Wagner and Co., of Dortmund, Germany, selected three machines for purposes of exhibition. One of these machines was the fully automatic plate perforating machine, illustrated in Fig. 10. This is the smallest of a range of five machines with pressure ratings from 25 tons to 250 tons. It is designed to handle plates up to 8ft 3in long by 4ft 2in wide and ⅝in thick.

The machine is of welded steel plate construction throughout and all its motions are push-button controlled from an operators' station, which can be set at any convenient point to give a clear view of work in progress without obstructing the means used for loading and unloading. The ram is mounted at the centre of the rigid bridge of the machine and is driven through a system of levers by a 4½ h.p. motor. Drive is transmitted through a gearbox giving an infinitely variable range of working strokes from 80 to 200 per minute, as the workplate on the table is fed below the ram.

The work is held on the table by pneumatic clamps, and the motors driving the rack for longitudinal table feed and spindle cross feed are interconnected so that the cross feed is effected at the same time as the return stroke of the table is being made. To reduce setting time separate motors are fitted to give high-speed approach travel of the work.

At present the firm has under construction the large planer illustrated in Fig. 11 and as this machine was too large to exhibit one of its tool-heads was shown. It is designed to plane work up to 11ft 6in wide, 39ft 5in long and 9ft 3in high. Each of the tool-heads on the cross rail is an individual unit driven by an electric motor, by which it is traversed along the rail and the tool slide is fed.

Side tool-heads are also fitted on each column of the machine. All motions and feeds are controlled from a separate operators' panel through push buttons and the feed rates are indicated by illuminated arrows on panels in the heads. When it is required to do bevel planing the horizontal feeds of the heads can be combined with the vertical feeds of the slides to give any desired angle.

This firm also showed an interesting machine, which it has developed in cooperation with Friedrich Kocks G.m.b.H., of Dusseldorf, for machining the circular pass rolls used in the manufacture of tubes and rods. In presenting this machine the makers point out that the generally practised method of truing worn tube rolls by removing them and machining them by pairs or singly and turning to profile with equal diameters by precision methods has a particular drawback. To obtain the best result to give precision of pass with the rolls in use a high degree of precision in assembly is required, and such precision is not generally attained in practice.

With the new machining method the rolls are not removed from their change frame but machined in it in exactly the same position as when rolling. The change frame is clamped on the profiling machine and the rolls driven in the same manner as in the tube mill whilst turning is carried out. The rolls as they rotate are machined by a number of cutters, corresponding to the number of rolls, set in a central cutter bar. The size and shape of the tools correspond to the size of the tube to be rolled, and as the rolls revolve the tools are fed into the work by rotation of the cutter bar.

Two models of horizontal universal presses for the automatic mass production of parts from endless steel strip were shown by Fabrique John-A. Chappuis S.A., of La Chaux-de-Fonds, Switzerland. One of these machines, known as the 2 by 20-ton model, is illustrated in Fig. 12, and is stated by the makers to be capable of outputs generally of about 50,000 units per hour, irrespective of the shape and number of operations performed.

This press has two workslides driven through connecting-rods and when using one connecting-rod the power available is 20 tons; with the two rods operating in conjunction 25 to 30 tons are available, and with the rods working independently each gives 20 tons. The slide stroke is just under 2in and the machine takes strip from 0·004in to 0·118in gauge up to 3⅝in wide, the maximum feed being approximately 4¾in.

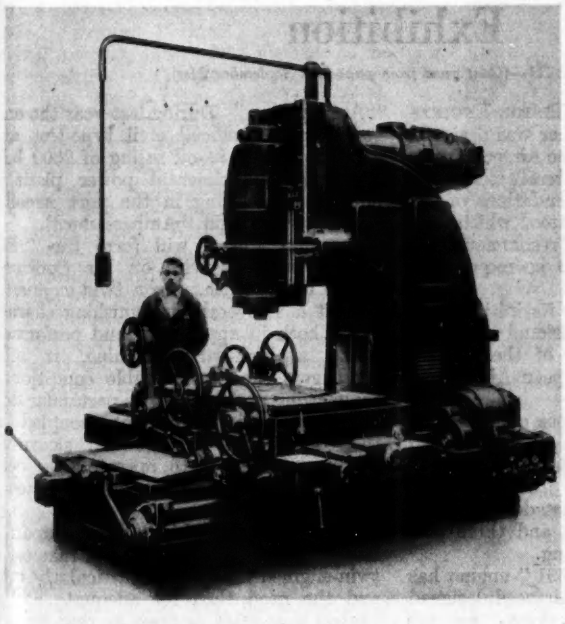


FIG. 9—VERTICAL MILLING MACHINE

FIG. 10—PLATE PERFORATING MACHINE

The crankshaft of the machine is driven through vee belts by a 4 h.p. motor and has three speeds, 80, 100 and 120 r.p.m. It actuates, through the two connecting-rods, a pair of hardened and ground steel slides, which move in cast iron cradles. To these slides the punches of the press tools are fitted with any standard type of die set either with or without columns. By setting two different sets of punches and dies side by side on the slides, the 20 tons power of the press can be used twice at each full revolution, provided the connecting-rods are angularly displaced to one another.

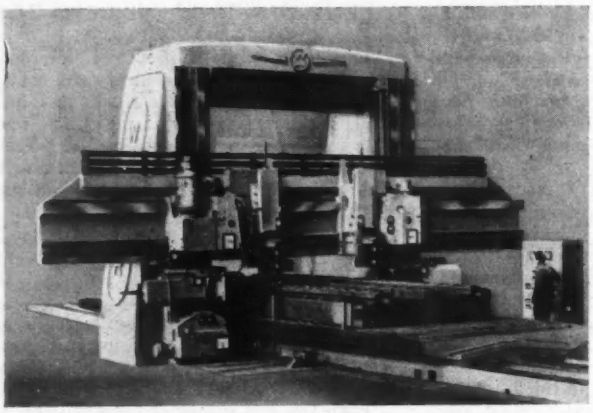


FIG. 11—LARGE PLANING MACHINE

Material is fed between the tools by spring-loaded feed rollers at the ingoing side and the strip is gripped by grooves about $\frac{3}{8}$in deep in the rollers. The horizontal arrangement of the tools makes setting and inspection very easy and all parts of the mechanism are designed to facilitate adjustment.

In the smaller 2 by 5-ton machine now being made by the firm, each connecting-rod is designed to exert a pressure of 5 tons on the working stroke and when they work simultaneously 6–8 tons are available. These machines are handled in this country by Stuart Davis, Ltd., Much Park Street, Coventry.

A machine of some interest shown amongst the welding plant at the exhibition was the large spot-welder made by S.A. Electro-mécanique, of 19 rue Lambert Crickx, Brussels, Belgium, which we illustrate in Fig. 13. This machine is carried on trunnions in a yoke, which is pivoted in an arm suspended from overhead girders or a gantry. Its throat is 1780mm deep and 900mm high and this large capacity, combined with the high degree of manœuvrability of the machine, adapts it for a wide range of constructional work over components of large areas such as railway carriage roofs. The lower arm carrying a welding electrode at its outer end is fixed, whilst the upper arm carrying a corresponding electrode is hinged. The pivoted arm is operated pneumatically to close the electrode on the work and its movement gives an electrode travel of up to 245mm.

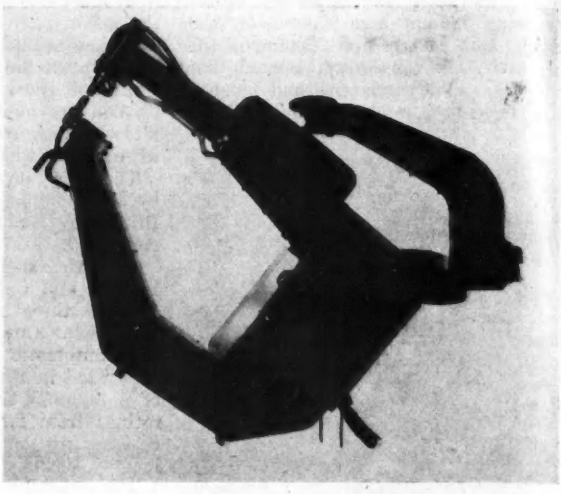


FIG. 13—LARGE SPOT WELDER

The spot-welding equipment includes an enclosure housing a three-phase transformer and apparatus for rectifying the secondary current. This transformer, with a maximum three-phase output of 200kVA, feeds a three-phase metal rectifier giving a direct current output of 30,000A. The power factor is stated to be better than 0·9. Since the welding is by direct current the introduction of ferromagnetic material between the electrode arms has a negligible effect on the secondary current and there is no need for the use of any compensating device.

The rectified current is fed to the electrodes by flexible conductors of ample cross section, which require no cooling, and the conductors are mounted along the inner sides of the welding arms, as shown in the illustration. The transformer secondary, the rectifier and the electrodes are cooled by a water-circulating system.

On a control desk, which can be positioned at some distance from the welding set itself, is arranged a comprehensive panel of push buttons, controls and indicators, including a push-button "on/off" contactor, an air pressure regulator, push-button controls for the motor used to swing the yoke on the arm, &c. On the set itself is an operators' control panel, incorporating push buttons for the welding operation and actuating the moving arm.

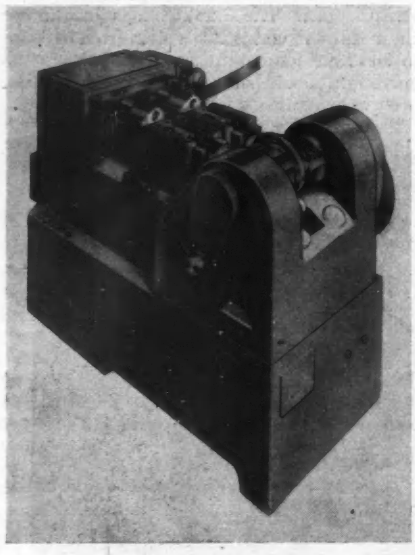


FIG. 12—2×20 TON PRESS

The S.B.A.C. Flying Display and Exhibition

No. III—*(Continued from page 374, September 21st)*

SOME CIVIL AIRCRAFT WITH PISTON ENGINES

THE "Ambassador" airliner was designed by Airspeed, Ltd.—now the Airspeed Division of the de Havilland Aircraft Company, Ltd.—to the broad recommendations of the war-time Brabazon Committee, which was formed to investigate and recommend the civil aircraft types likely to be required in the future.

The first prototype made its initial flight in July, 1947, and a provisional order for twenty developed versions of the aircraft was placed by British European Airways in December, 1947.

The two original prototypes and the first production prototype with the developed specification had, by the beginning of August, 1951, completed well over 1550 hours of test flying. The "Ambassador" has a certificate of airworthiness and three production aircraft are now flying.

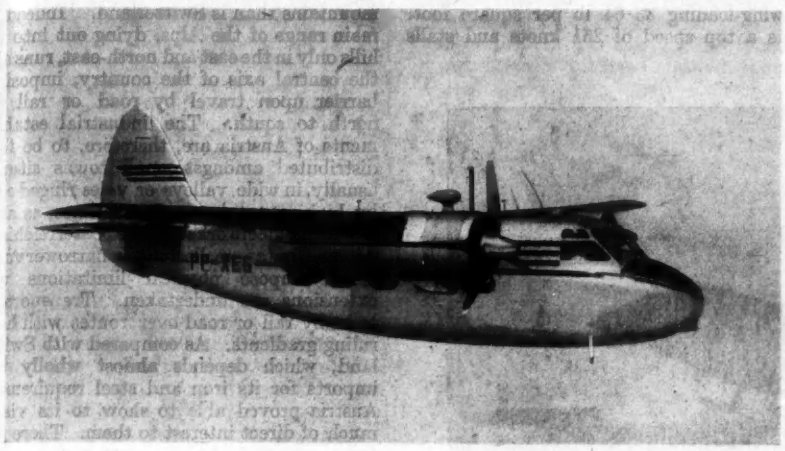
The Bristol "Centaurus 661" engine has been incorporated in an Airspeed-designed power plant specially developed for the "Ambassador." During last year the engine completed its official civil type-test at an exhaust-fitted take-off rating of 2600 b.h.p., while the experimental power plant had already been flying in the port nacelle of the first prototype "Ambassador."

"Ambassadors" will form the "Elizabethan" class service on the Continental routes next month. As a twin-engined airliner it has several distinguishing characteristics, both in appearance and performance. Being a high-wing machine, it affords passengers the best possible conditions for the viewing ground and its particular degree of aerodynamic refinement, coupled with the use of the latest radial sleeve-valve engines, enables it to operate (less certain non-flying costs) at 1·25–1·50 pence per passenger mile.

The situation which ensues upon the failure of an engine during the take-off of a twin-engined machine is particularly critical and the need then for adequate and safe control is at least as great as that for a safe

rate of measured climb. One of the "Ambassador's" outstanding characteristics is its viceless behaviour in extreme asymmetric conditions. Many pilots have tried the aircraft and they have been unanimous in their evaluation of its behaviour in the worst cases of power failure.

Early in April final development flying with the production prototype had reached the stage at which full-load engine-cut take-off's could be demonstrated, even at a maximum gross weight of 52,500 lb. The aircraft could be kept straight after an engine cut from full power at 50 knots and a normal take-off could be continued at any speed above, say, 90 knots.



THE PERCIVAL "PRINCE"

This machine has publicly demonstrated circuits, including taxi-ing, with one engine feathered. The aircraft seats forty to forty-nine passengers and is pressurised to maintain a cabin "altitude" of 8000ft, when cruising at 20,000ft. It has a number of cruising conditions to suit particular ranges and one stage distance with S.B.A.C. instrument flight allowances, cruising at 10,000ft and 240 m.p.h. with full tanks is 1015 miles, the payload with this range being 8000 lb. The capacity payload is 11,650 lb and the range 350 miles. The take-off distance to 50ft on one engine at its maximum weight of 52,500 lb is 1500 yds.

Another twin radial-engined high-wing passenger aircraft now in quantity production is the "Prince" which is made by Percival Aircraft, Ltd., now a member of the Hunting Group of Companies. The current production version, the Mark III, carries eight to ten passengers and has two Alvis "Leonides" nine-cylinder radial engines, developing 550 h.p. each. The span is 56ft, length 42ft, the all-up weight 11,000 lb and its wing loading 31·1 lb per square foot. With eight passengers and 300 lb of baggage, it has a maximum still-air range, without allowances, of 1170 miles at 151 m.p.h., cruising speed. The "Prince" has a top speed of 229 m.p.h. at 5000ft, and stalls with flaps down and without power at 75 m.p.h. Its maximum rate of climb is 1650ft per minute and a distance of 760 yards is required to clear 50ft from take-off. It has a notable performance on one engine and in that condition from take-off can clear 50ft with a run at sea level of 1100 yards. There are several versions of this particularly versatile aircraft in production. Amongst them is one adapted for survey work and another for ambulance duties. It has been adapted by the Royal Air Force and the Royal Navy for many aspects of military training and for communication purposes.

Light Aircraft and Trainers

There were demonstrated at Farnborough examples of the two training aircraft upon which pupil pilots are now to receive in two distinct stages all their instruction before passing on to fully operational military aircraft. The new basic trainer, whereon pupils will commence flying training is the Percival "P.56" "Provost".

The "Provost" is an all-metal, side-by-side, two-seat basic trainer designed for all-weather flying, with full radio aids and quickly retractable amber screens for simulated blind flying training. The "Provost" is powered by a 550 h.p. Alvis "Leonides" engine, has a maximum speed of 200 m.p.h., a maximum weak mixture cruising speed of 185 m.p.h., and a still-air range (no allowances) at 136 m.p.h., at 5000ft of 660 miles. The service ceiling is 25,000ft and it will climb to 10,000ft in 6·5 minutes.

Amongst the installations in the "P.56" are V.H.F. radio, tunable beam approach equipment, full night-flying equipment, blind flying instruments, removable amber-tinted panels and wind-screen wipers. The wing has pneumatically operated slotted flaps and the wing-tips are detachable.

The fuselage is of semi-monocoque construction with large hinged panels for access to accumulators, radio, controls and other equipment in the fuselage. Fixed oleo-pneumatic undercarriage legs are easily detachable from the wing, for replacement, and have wheels incorporating differentially controlled, pneumatically operated tube brakes.

The British Air Ministry Specification T.16, to which the Percival "P.56" Basic Training Aircraft has been designed is an acknowledgment of the success of the Royal Air Force post-war scheme of pilot training.

This training scheme is fundamentally different from the earlier one in that the "elementary" light aeroplane is dropped in favour of a heavier and more complicated aircraft, which has become known as the "Basic" Trainer. The comprehensively equipped basic trainer with its radio aids can give the student more useful flying hours in all weathers than could the earlier simple, elementary types and therefore the hours required on the second stage heavier types can be drastically reduced in the interests of economy. Its additional power and consequent much improved rate of climb enables aerobatic height to be gained much more quickly and to be maintained throughout aerobatic practices.

Special study has been given to manœuvrability coupled with lightness of controls and a high rate of roll. The side-by-side seating arrangement provides the best conditions for imparting flying instruction, particularly for landing and take-off exercises, at which times it is also the safest. The pupil also becomes accustomed to flying from one side of the aircraft's longitudinal axis.

It is stated that only by beginning the student's training on a basic type, such as the "P.56," can the two-stage training scheme be maintained, carrying out as much of the total flying training syllabus as possible on this economical basic type. In the days of the light training aircraft, which were not equipped with "blind landing" radio aids, &c., the maximum useful hours on the type was found to be about sixty, which left some 140 hours for the advanced stage. The costly applied trainers need then only be used for a short conversion stage to accustom the student to faster and larger aircraft and to the use of weapons before proceeding to operational types.

THE PERCIVAL "PROVOST"

The advanced trainer, named the "Bal-

liol," is made by Boulton Paul Aircraft, Ltd., Wolverhampton. It has been selected for service with the Royal Air Force after a lengthy and searching series of competitive trials. The "Balliol" II is a single-engine, all-metal, two-seat advanced Service trainer for day and night instruction in flying, navigation, gunnery, bombing, rocket attack and photo-reconnaissance or for use as a glider tug.

The power unit is a Rolls-Royce "Merlin 35" twelve-cylinder "vee" liquid-cooled engine, rated at 1240 h.p. at 9000ft, and with 1280 h.p. available for take-off at 3000 r.p.m. and +12 lb per square inch boost.

This "Merlin" engine has been specially developed for use in trainer aircraft. It is designed for running periods of 1000 hours between overhauls and will give long, unattended service in any climate.

The aircraft has a retractable undercarriage with a high shock-absorbing capacity, which reduces the liability to damage anticipated in training service.

The steerable tail-wheel provided makes the use of brakes for normal steering on the ground unnecessary and the wide track of the undercarriage also contributes to longer brake life, as does the use of bi-metal brakes, which reduce thermal distortion.

Main assembly attachment points are of the simplest type, with the result that replacement of major assemblies can be effected without difficulty, using standard equipment. The inner main planes are detachable at the fuselage, facilitating transport, replacement and repair of damage arising from belly landings.

As can be seen from the scheduled data, the pneumatic and hydraulic services, accessories and the performance are comparable to those of the single-seat fighters in use during the recent war, and the wing-loading, control forces and rapidity of response about all three axes are, in fact, very similar to those of the latest types of fighters now going into service.

The successful development of the "Balliol's" design has been assisted by the technical departments of the Air Ministry and of the Ministry of Supply.

The aircraft has V.H.F. and beam approach radio. The normal all-up weight is 8410 lb, and the wing-loading 33·64 lb per square foot. It has a top speed of 251 knots and stalls with flaps down at 75 knots.

Mention must be made of the all-metal, high-wing "Pioneer" machine, made by Scottish Aviation, Ltd., Prestwick, Ayrshire. Fitted with large area flaps and full leading edge slats this machine can maintain height at a little over 36 m.p.h. and can become airborne after ground runs of thirty to seventy-five yards, according to load. It has an Alvis "Leonides" engine and, operated with pilot and four passengers with baggage, the "Pioneer" has a range of 400 miles at a speed of 120 m.p.h., and has a maximum cruising speed of 140 m.p.h. For slow-flying duties such as crop dusting and aerial photography the fuel consumption is only ten gallons per hour. The gross weight is 5400 lb and the wing-loading 13·2 lb per square foot.

Also demonstrated was the latest version of the well-known "Auster," the Model S, made by the Auster Aircraft Company, Ltd. It has a Cirrus "Bombardier" engine of 180 b.h.p., driving an "Aeromatic" automatic variable-pitch propeller. The machine is fully aerobatic. The all-up weight is 2025 lb, run to clear 50ft, 240 yds, range 230 miles, cruising speed 102 knots, and stalling speed about 33 m.p.h.

THE BOULTON PAUL "SEA BALLIOL" T.21

(To be continued)

Iron and Steel Institute in Austria

No. I

SINCE the war the Iron and Steel Institute has reverted to its pre-war practice of holding annual summer meetings alternately at home and abroad. In 1947 the Institute went to Switzerland, two years ago it went to Norway, and this year the meeting was held in Austria. As it happens, each of these countries is mountainous. Yet the physical characteristics are different. In Norway, the mountains impose immense handicaps upon land transport. But great fjords, penetrating far inland from the sea, permit ships to reach industrial establishments placed where they can best benefit from the situation of natural resources and from the great reserves of water power available. Industrial areas as we know them in this country are not to be found. The majority of works are isolated, having adequate access only by sea. By contrast, in Switzerland, the fact that the mountains run down to foot hills in the north has permitted such industrial cities or towns as Zurich and Winterthur to grow up and rail and road transport, to north, to west and to east is not seriously hampered by the terrain. The situation is different again in Austria. Save perhaps in the east and around Vienna—an area now occupied by the Russians, which was not visited by the members of the Institute—Austria is more completely covered by high mountains than is Switzerland. Indeed, the main range of the Alps, dying out into foothills only in the east and north-east, runs along the central axis of the country, imposing a barrier upon travel by road or rail from north to south. The industrial establishments of Austria are, therefore, to be found distributed amongst small towns situated, usually, in wide valleys or vales ringed about by high mountains and sometimes, as at the Donawitz steelworks of the Osterreichische-Alpine Montangesellschaft, in narrower valleys which impose physical limitations when extensions are undertaken. Transport has to be by rail or road over routes with heavy ruling gradients. As compared with Switzerland, which depends almost wholly upon imports for its iron and steel requirements, Austria proved able to show to its visitors much of direct interest to them. There is, in fact, a great deal to see even in the western and more mountainous part of the country that is at present occupied by British and American troops. For the Austrian iron and steel industry makes a far from unsubstantial contribution to the iron and steel production of Western Europe as the following table shows.

TABLE I—*Austrian Production*
(Thousand Tons)

Product	1937	1947	1948	1949	1950	1953*
Iron ore ...	1885	878	1189	1488	1860	2450
Pig iron ...	389	279	613	838	883	1200
Crude steel	650	357	648	835	947	1300
Rolled steel products	427	238	387	534	584	900

* Planned.

At the end of the war the Austrian iron and steel industry was very much disorganised. Certain parts of the country, now under American or British control were first "liberated" by the Russians, who, during the short period they were there, partially or completely dismantled certain plants. There is some evidence to suggest that some, at least, of the plant so removed, never reached Russia and now, to the benefit of no-one, is rusting away in railway goods yards in Eastern Europe. Furthermore, the Germans, after Hitler's annexation of Austria, made the Austrian industry subservient to the German. When the war ended, therefore, there was in Austria a heterogeneous collection of plant and, in particular, primary production was swollen out of all proportion to the finishing section. Again, under German influence, much water power that had been developed immediately before or during the war was designed to be exported to Germany rather than for use in Austria. A great water power plant in the extreme west, for instance, was not connected by transmission line to the consuming areas in the east but to Bavarian industry instead. Apart from the handicaps imposed by war, the Austrian industry is also handicapped by the shortage of indigenous coal. There are, it is true, extensive mines at Voitsburg. But the product, mainly of lignite, covers barely 25 per cent of requirements. Upon the other side of the account, as members of the Institute were able to observe for themselves, there is still no

shortage of scrap in Austria. Envious eyes, indeed, were cast upon the "mountains" of scrap seen in various works. Nor is ore scarce. There are several sources within the country's boundaries, and one of them, the Erzberg is famous as the Styrian "iron ore mountain." There is here a store of some 350 million tons of high-grade ore, containing some 30 per cent of iron.

The large increase in output of the Austrian Iron and steel industry since 1947, revealed by Table I has been, and is being brought about very largely by the help of Marshall Aid. The whole industry in fact, is in course of re-organisation and modernisation. Some £16 million was spent upon that purpose between 1947 and 1949, and the current investment programme involves a further expenditure of £27 million. Under the latter programme rationalisation and concentration is being brought about. Pig-iron production is to be concentrated at Linz and Donawitz (see accompanying map, Fig. 1). Old and inefficient plant is to be replaced. At Linz, a modern semi-continuous hot strip mill is being installed. The production of special and alloy steels is to be concentrated in two producing groups instead of four as previously, and alloy steel sheet production will be concentrated at Hönigsberg/Murzzuchlag. Structural steel bars and hot rolled narrow strip of commercial quality will be produced at Donawitz and Kindberg. Table II shows the major investment projects included in the 1950/52 programme. At the same time, progress is being made with the development of the very large water power potentialities that the country enjoys. A large proportion of Austria's steel production is exported. According to the statistical bulletin issued by the British Iron and Steel Federation in connection with the Iron and Steel Institute meeting in Austria (from which Tables I and II are drawn) Table III gives an official Austrian forecast of exports in 1952.

TABLE II—*Major Investments Projects*, 1950–52

Project	Expend.† $000	Supplem. Expend.†	Total Expend.†
		(mil. schillings)	
Erzberg (iron-ore mountain)	1101	28·1	52·1
Modernisation of steel-making dept., Donawitz	—	40·0	40·0
Blooming mill at Donawitz	242	53·6	59·9
Continuous billet mill, Donawitz	2191	59·6	107·9
Rail and structural mill, Donawitz	4407	35·8	131·2
Rolling mill III (hot) at Kindberg	—	18·6	18·6
Cold strip mill at Krieglach	660	7·2	21·4
Expansion of steel-making dept., Linz	543	52·9	64·4
Slab mill, Linz	1844	51·6	91·0
Hot strip mill, Linz	5780	65·0	188·5
Conditioning dept., Linz	66	20·3	21·7
Cold mill, Linz	2100	36·0	81·7
Blooming mill, Kapfenberg	1345	69·3	98·0
Sheet and plate mill, Hönigsberg	1500	34·1	66·1
Expansion of Ternitz Steel Plant	—	35·7	35·7
Liezen steel plant	—	10·0	10·0
Totals	21,779	617·8	1088·2

† Not converted into £, since no indication is given as to which of the several official conversion rates is applicable.

TABLE III—*Export Forecast*, 1952
(Thousand Tons)

Area of Destination	Bars rolled wire, &c.	Sheets	Special and alloy steel	Total
O.E.E.C. countries	25	25	28	78
Eastern block ...	5	15	12	32
Yugoslavia ...	10	15	8	33
Dollar area ...	—	—	3	3
Near East ...	10	10	4	24
Spain	—	3	3	6
Others	3	22	12	37
Total	53	90	70	213

At present, it will be observed from the foregoing introductory account, the Austrian iron and steel industry is in a transition stage. That fact was obvious enough to the members of the Institute as they visited various plants. For much of the plant now in operation is outdated and old, though no complaint can be made about the quality of the product. Side by side with such plant new plant is already operating or is in course of installation. The energy with which modernisation is being carried out is transparently obvious and the fact that so much of the plant is labelled to that effect shows what good use is being made of Marshall Aid.

One further point needs to be put on record before we begin a more detailed account of what we saw in Austria. Everywhere that the members went they were greeted with the utmost friendliness. Nor did the Austrian welcome stop at friendliness alone. Musical honours accompanied the Institute! Often as the Institute special train drew into a station, it found a "Miner's Band" in black uniforms and wearing hats carrying jaunty white plumes, there to welcome it. After lunch, and again upon departure, the band would be present. Often a large proportion of the inhabitants of a town or village would turn out to provide a welcome or to say "goodbye." And at more official welcomes or evening receptions, the Austrians, as a musical people, made sure that a more serious concert should form a part of the proceedings. Many a member of the Institute, long before the tour was ended, had already made up his mind soon to return to this beautiful country and its friendly people, not upon business, but upon holiday.

In writing of the experiences of the Institute in Austria, we intend as strictly as may be, to relate only those happenings of which we had first-hand knowledge. Many works were visited by the members. We had to make our choice amongst them, and though we may make a passing reference to places that we did not visit, our account must, in the main, be restricted to those which we, in person, saw.

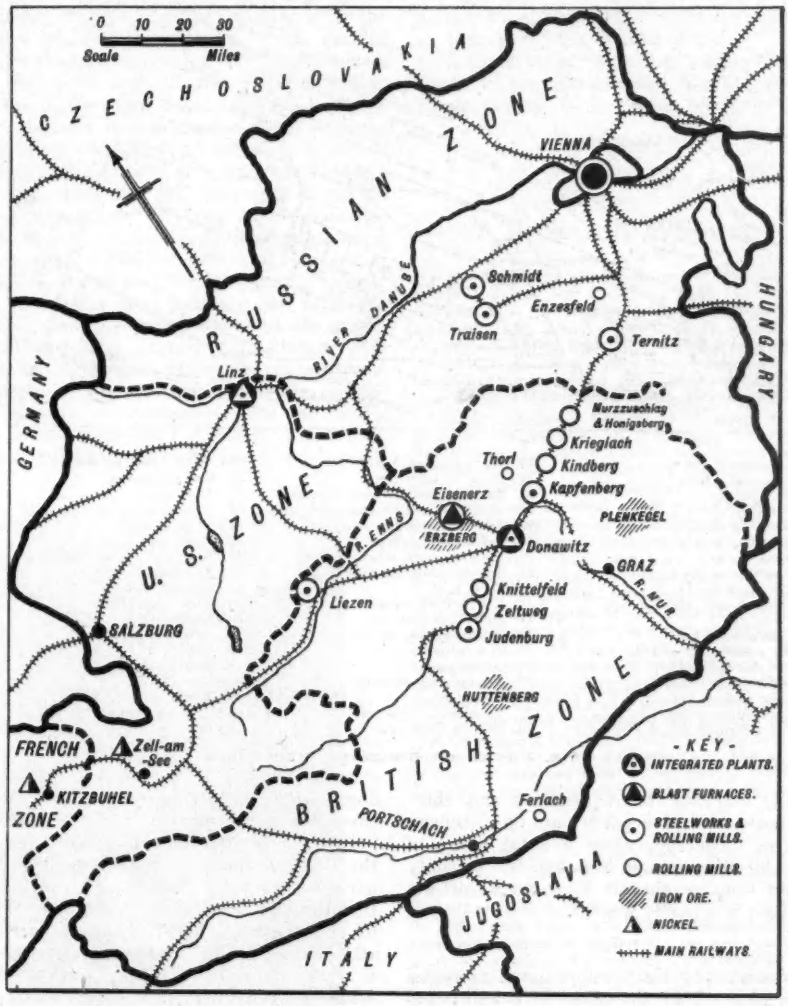
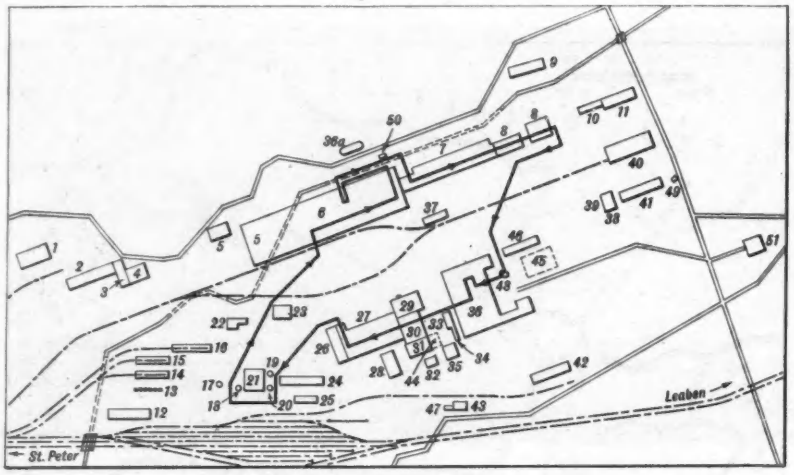


FIG. 1—MAP OF AUSTRIA

TRAVELLING TO AUSTRIA

The programme of the Iron and Steel Institute Meeting in Austria was divided into three sections. Section A, from September 6th to 8th, was held at Gmunden, near Salzburg. Section B, from September 9th to 15th, took the members to Graz in Styria and Pörtschach in Carinthia; and Section C was held at Zell-am-See in the Tyrol. For a number of reasons, we were unable to attend Section A, during which visits were made to Vereinigte Oesterreichische Eisen-und Stahlwerke A.G., Linz, to Vereinigte Aluminium Werke A.G.,

Mattigwerke and to Oesterreichische Metallwerke A.G., Ranshofen. For our part we went out by Sabena airliner on September 8th to join the meeting at Graz. We have only two comments to make about that journey. We had to change aircraft at Brussels and a delay of an hour, though long by railway standards, was not, we suppose, unreasonable. But between Brussels and Salzburg, the terminus of our flight, the aircraft called at Frankfurt and Munich. At both places, though in transit, we had to alight, carrying hand luggage, and show passports, and give particulars of currencies carried. Thereby, since a total delay of some 90 minutes was imposed, the capacity of our Convair aircraft to travel at 400km per hour was partly wasted.



1. Dressing of billets
2. Dressing of rods
3. Distribution
4. Dressing of "I" beams
5. Dressing of rails
6. Heavy rolling mill
7. Steel works
8. Electro-steelwork
9. Pattern shop
10. Soaking and heating shop
11. Foundry
12. Coke storage bin
13. Air roasting kilns I-VI
14. Ore storage bin I
15. Ore storage bin II
16. Coke storage bin
17. Blast furnace No. 1
18. Blast furnace No. 2
19. Blast furnace No. 3
20. Blast furnace No. 4
21. Pouring hall for blast furnace
22. Pumping station and work bath
23. Blast engines, gas-driven
24. Boiler and pumps
25. Blast engines, steam driven
26. Turning shop for rolls
27. Sheet mill
28. Locomotive house
29. Main boiler house
30. Electric power station
31. Power house
32. Oxygen plant
33. Administration building
34. Laboratory
35. Mechanical repair shop
36. Small rolling mill
36a. Water cooling towers
37. Gas producers
38. Alloy store
39. Ingot machining shop
40. Machine shop
41. Boiler and forging shop
42. Refractory brick factory
43. Testing laboratory
44. Oxygen plant } in erection
45. Converter plant }
46. Spare parts store
47. Gate No. I
48. Gate No. II
49. Gate No. III
50. Gate No. IV
51. Works hotel
—— Iron and Steel Party Route

FIG. 2—PLAN OF DONAWITZ STEELWORKS

GRAZ

Graz is a tidy, clean and pleasant industrial town situated in the midst of a well-populated area in the wide vale of the river Mur which flows southward into Yugo-Slavia. It was here that the Institute held its only technical session of the tour. On Monday, September 10th, the members were given a formal reception in the Stefaniensaal on behalf of the Austrian Reception Committee, the State of Styria, the City of Graz and the University of Leoben. Dr. J. Oberegger, Managing Director of the Oesterreichische-Alpine Montangesellschaft, Leoben and president of the Eisenhütte Osterreich presided as chairman of the Austrian Reception Committee and, after the playing of some delightful introductory chamber music, welcomed the members of the Institute to Austria. Professor Platzer, Rector of the Montanistiche Hochschule, Leoben, then welcomed them on behalf of the University of Leoben. The meeting was also honoured by the presence of the Austrian Chancellor, and the Minister of Transport, both of whom also welcomed the members. The president of the Institute, Mr. Mather, chairman and managing director of the Skinningrove Iron Company, Ltd., stressed in his reply, that one of the Institute's reasons for holding meetings abroad was to establish personal relationships with iron and steel men in the country concerned. Proceedings concluded with the playing of more chamber music.

There followed a luncheon out-of-doors on top of the Schlossberg, a mountainous outcrop several hundred metres high, upon which the original castle of Graz was situated, dominating the river Mur and the valley through which it flows.

In the afternoon at a technical session in the Stefaniensaal, a paper on "Investigations into the Effect of Non-Metallic Inclusions on the Hot-Workability of Steel," by F. Rapatz and M. Strobich was presented and discussed. Dr. Chesters then presented a very interesting lecture on "Recent Advances in British Open-Hearth Furnaces." It included the showing of a film in which analogies were drawn between the flow of the gases in a furnace and the flow of water in a mountain stream. It occurred to us that those who are investigating gas flow in furnaces might do well to take up fly-fishing. For the presence of eddies and whirls in water flowing amongst rocks is well known to anglers! The following is a synopsis of the lecture.

SYNOPSIS

The open-hearth furnace is a complex unit, any change in which tends to react on the structure and operation as a whole: thus, refractory life depends on flow pattern within the furnace and permissible combustion practice is limited by the refractories available. During the last few years a concerted effort has been made in Great Britain to provide the fundamental data needed for scientific design and operation of open-hearth furnaces. The paper indicates the general line of approach. It does not attempt to give detailed information, or to cover the steelmaking aspects of the problem.

Aerodynamics.—The work of Dr. A. H. Leckie and his British Iron and Steel Research Association colleagues on a one-fifth scale hot model of an open-hearth furnace, and the co-operative investigation by the United Steel Companies, Ltd., and the British Coal Utilisation Research Association on "The Influence of Port Design on Open-Hearth Furnace Flames," has been followed by extensive work in a number of laboratories on air, water and hot models. These researches have now reached the stage at which full-size furnaces are being built on the basis of model data and flow patterns developed in two and three-dimensional water models are being used in the design of actual furnaces. The distribution of refractory wear has been explained in terms of flow pattern and changes in design suggested by flow pattern work have already led to improvements in refractory life.

For oil-fired furnaces the general trend is towards single-uptake designs, which give faster mixing and combustion and, therefore, greater output, and in addition make for longer roof life. The sloping of the end walls facilitates protection of the roof and side-walls from flame impingement and substantially reduces end-wall wear.

Future development calls for simplicity and symmetry of flow pattern, so that the desired conditions can be specified and subsequently obtained. The relation of flow in furnaces to the more usual phenomena of flow around such things as boats, aeroplanes and motorcars, has been studied.

Refractories.—Although the main roof only accounts for about 10 per cent of the total refractories and bricklaying labour costs on an open-hearth furnace, attention is still focussed on it, because it limits more than any other section both the output rate and the furnace availability. Substantial improvements in roof life have been obtained by the use of low alumina silica bricks of high bulk density and by all-basic construction. The most remarkable results on silica have been obtained by the use of South African quartzite, the alumina content of bricks made from this material being only about 0·3 per cent and the porosity roughly 10 per cent below normal.

Since the war six furnaces in Great Britain have been converted to all-basic construction. One of these has already had a roof life of well over 1000 heats in spite of an increase in output rate of about 30 per cent. At other plants, experience has not been so favourable and big improvements both in basic brick quality and in design and operation are required before such furnaces become generally economic. Fast driving at appreciably higher than normal roof temperature is advocated to keep the bills for fuel and overheads below the silica furnace level.

Combustion.—Rapid strides have been made in instrumentation and automatic control and it is now widely agreed that all open-hearth furnaces should be fitted with instruments to indicate and where necessary record fuel flow, air flow, furnace pressure, roof temperature and checker temperatures. With liquid fuel fired furnaces the steam used for atomisation should also be metered. The intelligent use of such instruments has enabled outputs to be raised without a corresponding increase in refractory costs. Indeed, a major advantage of roof pyrometer control is the improvement in life obtained where the roof is kept below 1650 deg. Cent.

During the last few years a number of firms have completed or fitted automatic controls, in particular roof temperature-fuel flow and furnace pressure-stack damper linkage. Most of them claim an advantage more than sufficient to offset the extra cost of installing and maintaining such equipment.

At a reception that evening in the Burg, Graz, given by Landeshauptman J. Krainer, Governor of the State of Styria, the members found themselves, at first, invited to sit upon chairs on the lawn. A piano was brought out on to the floodlit porch of the house and the members were treated to the singing of arias from operas and other songs by operatic singers from the city's opera house, a very delightful interlude.

LEOBEN AND DONAWITZ

The following day the members of the Institute travelled by train up the valley of the Mur to Leoben. A few miles above Graz, the valley narrows and the railway, together with a road, keeps close to the river. It was thus possible to observe how the water power in the river, whose fall is by no means very rapid, has been developed. At intervals, low dams, usually equipped with large floodgates, have been thrown across the river, and its waters diverted into canals leading to power stations operating under heads up to, we

estimated, about 30ft. So much of the water is diverted that, at least in September when there is little water flowing, the merest trickle runs down the stream bed. Elsewhere, local factories have diverted a smaller proportion of the total flow to provide their power needs.

At Leoben, the members walked from the station behind a band to the Hochschule, to attend a reception in its main hall. Once they were seated, the professors arrived, robed, in stately procession from the back of the hall to the dais. The welcome was given by the Rector, Professor Platzer, on behalf of the University of Leoben, and by the Burgomaster on behalf of the town. In reply, Sir Charles Goodeve, Director of Research, the British Iron and Steel Research Association, remarked that he believed international scientific organisation to be more than ever necessary at the present time. One of the reasons why the members had come to Austria was the beauty of the country, its friendly people, its music and its poetry. But they had also come to learn. For those who were concerned with iron and steel must remain students all their lives. Austria, it was clear, had many problems to face that were similar to Britain's. Members would find a stimulus to continue their own rebuilding by seeing the similar work that was being carried on with such great energy in Austria. Britain, like Austria, had financial problems relating to the dollar and to oversea trade. The Austrian steel industry was nationalised. Members might, therefore, learn something from Austria about the running of a nationalised steel industry. The University was the *alma mater* of the Austrian iron and steel industry. It was also the *alma mater* of many non-Austrian former students abroad. Those who studied steel and iron were a fraternity of peoples unseparated by frontiers. The Hochschule had played a large part in the development of methods through its research work. There was, he felt, much room for co-operation in international research and having made contact with the Hochschule, members would hope to learn more of what was being done there. In conclusion, he emphasised that there would be a welcome in Britain for any Austrian iron and steel men who came to see the work of B.I.S.R.A. and the works of British companies.

After a luncheon at Donawitz, given by the Oesterreichische-Alpine Montangesellschaft the members visited the Donawitz works, of which a plan is given in Fig. 2. In the photograph reproduced in Fig. 3, the blast-furnace plant can be seen on the left and towards the right a row of chimneys reveals the position of the melting shop. Some 5000 workers are employed and the present rate of output is about 380,000 tons of pig iron, 500,000 tons of crude steel and 400,000 tons of semi-finished and finished rolled goods per year.

The blast furnace plant consists of three coke blast furnaces with all supplementary equipment, and a maximum daily capacity of 1250 tons. Large ore dumps supply six modern roasting furnaces, built on the Apold-Fleissner system, dealing mainly with the lumpy ore, and two sintering strips for fine ore, so that the ore reaches the blast furnaces on the whole roasted and sintered. Flux materials, like quartz and lime are available from deposits in the neighbourhood recently opened up. In twelve 30-ton and one 60-ton open-hearth furnaces, in a somewhat elderly melting shop, the pig iron introduced in liquified state is smelted, with additional scrap and ore, to make high-quality Donawitz crude steel. Five electric arc furnaces of 0·5, 7·5, 10, 15 and 20 tons capacity permit the whole range from ordinary steel up to the highest quality super-speed steel to be made.

The members learned during their visit that an up-to-date blooming mill, with a capacity of up to 70,000 tons per month, was already in commission. But the expansion of the heavy mill is still in process. A continuous billet mill with ten stands, which lies on the extended axis of the blooming mill, will make it possible to roll the rough ingot in one heat into billets or slabs in any desired size. With the help of a heavy section mill, the primary product can, if desired, be made into heavy bars up to 185mm diameter, in any quality desired; furthermore, into girders; into heavy angle iron; or railway and tramway rails of many local and foreign profiles, including the essential superstructure materials such as bed-plates, fish-plates, &c. The semi-wrought product which leaves the blooming mill is used either as a primary product for the Donawitz fine mills, which are supplemented by the Kindberg rolling mills; or it is supplied to other firms of the combine and to outside buyers as a primary product.

The Donawitz fine rolling mill consists of a continuous Morgan wire mill delivered by the United States in 1910, which produces steel and special wire from 5·5mm upwards; and further, a modernised light mill which produces iron bars up to 28mm diameter and corresponding profiles; as well as a medium mill which produces bars up to 72mm diameter and also the other corresponding profiles. A modernly-equipped factory for the production of refractory chamotte and dinas bricks, a large grey iron foundry and many auxiliary plants complete the installations at the Donawitz works. The main source of energy is electric current, which is for the most part produced from blast-furnace gas, but also from the steam of the work's boiler plant. The girder mill, the trio rolls and the plate rolls are also driven by steam. The works is connected to the appropriate public grid.

In the evening there was a reception and dance in the Kammersaal, Graz, given by Burgomaster, Dr. E. Speck, Mayor of Graz.

(To be continued)

FIG. 3—DONAWITZ STEEL WORKS

Technical Reports

Some German Experiments in the Gasification of Washery Rejects and Pulverised Fuel. Information Bulletin No. EG(51)9. Production Department, National Coal Board.—The bulletin outlines the attempts made in Germany to find an economical process for gasifying rejects from washeries. Work has been done on the gasification of high inert material and the batch process has been used, in which the charge is gasified in a refractory-lined oven and the gas drawn off at the top or the bottom. The process has gone out of use since the war. A retort for low temperature carbonisation of oil shale, known as the "Hubofen," is illustrated by a diagram and mention made of a vertical retort for low temperature carbonisation of shale, which has gasified low-grade washery rejects successfully. A pilot plant, which was used for experiments with washery rejects, is described and the composition of the material used and the gas produced is given. The results of the experiment are discussed and based upon these a new plant was built, having a daily throughput of 400 tons. In an appendix the economies of working such a plant are outlined. A small cyclone furnace for the gasification of pulverised fuel is described and drawings give details of the pulverised fuel burner and the cyclone slagging chamber. Experimental data from the cyclone furnace is tabulated and the analysis of the gas obtained from brown coal is given and also the composition of the dust from hard coals.

The Torsion of Aluminium Alloy Structural Members. By M. S. G. Cullimore, Ph.D., and A. G. Pugsley, O.B.E., D.Sc. The Aluminium Development Association Research Report No. 9. Price 7s. 6d., post free.—The British Standard 1161 represents a stage in the development of aluminium alloy sections and this report gives the results of experimental work carried out to increase knowledge of the basic torsion problem of aluminium alloy structural members. Pure torsion tests were carried out to establish suitable experimental technique and an apparatus designed for torsion testing. Torque-twist curves for certain sections are given and also curves relating longitudinal strain with angle of twist. Existing methods of estimating torsional stiffness are reviewed and tests made to establish empirical constants for formulæ applicable to angles and channels, the results are examined graphically and the values of the torsion constant, obtained by various methods, are tabulated. Torsional strength is considered and diagrams give lines of shear stress from soap-film experiments for "L"-shaped junctions. The values of the maximum stress concentration factor obtained for various fillets are plotted for comparison, with results given by other methods, and the development of plasticity in "L"-shaped cross-sections is investigated by the sand-heap method. Proof torque is defined and experiments carried out to establish the influence of fillet radius size on the proof torques of angle sections. The existing theory of non-uniform torsion is examined and the results of experimental work upon a 3in by 1½in "I" beam are shown graphically to indicate variation of angle of twist and longitudinal stress. An appendix to the report gives a summary of the basic torsion theory and a series of tables lists the torsion constants for the structural sections given in B.S. 1161 : 1951.

Metallurgical Topics

Graphitisation in Heat-Resisting Molybdenum Steel

THE extensive literature of graphitisation in steels used for superheated steam pipes has been reviewed in detail by H. J. Wiester.[1] Interest was roused in the subject by the sudden fracture in 1943 at an American power plant of a welded superheated steam pipe made

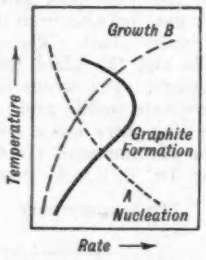


FIG. 1—*Diagram Indicating Influence of Temperature on Rate of Graphite Formation*

of steel containing carbon 0·14, molybdenum 0·50 per cent, and operating at a temperature of 510 deg. Cent. The fracture occurred through a deposit of graphite near the outer edge of the heat-affected region of the weld. Examination of material from other power stations revealed similar instances of graphitisation; but the symposium on "Graphitisation in Steam Piping," held in the following year, did not provide a complete solution of the difficulty. Since then, many papers on graphitisation have appeared, mostly in America, and research on the subject is still being actively undertaken.

The most important work is probably that carried out in the Battelle Memorial Institute and published by S. L. Hoyt and his collaborators. In this the process of nucleation and growth was investigated. The rate of formation of nuclei and of their growth may be represented graphically by curves *A* and *B* in Fig. 1. The rate at which graphite forms will therefore go through a maximum as the temperature to which the steel is exposed rises. This maximum occurs at a temperature a little below Ac_1, i.e., at about 600 deg. to 680 deg. Cent. There is a period of induction which diminishes as the temperature rises to the above value, after which graphitisation proceeds in the manner indicated by the curves in Fig. 2. A content of 0·5 per cent molybdenum retards graphite formation without preventing it. Both in carbon steels and in steels containing molybdenum graphitisation is favoured by strong deoxidation by aluminium. Eliminating, or at least reducing, the aluminium used as a deoxidiser decreases the susceptibility to graphite formation in the resulting product. A chromium content of upwards of 0·5 per cent usually eliminates graphitisation or at least arrests it for a time sufficiently long to prevent its occurrence during the normal expected life of high-temperature steam installations. The addition of chromium is probably the most practical method of counteracting the tendency to graphitisation.[2] The carbide-forming elements titanium, vanadium and niobium exert a similar effect and may also give enhanced resistance to creep. On the other hand, graphitisation takes place more readily in nickel and nickel-molybdenum steels. In the heat-treated condition the steels exhibit an enhanced tendency to graphitisation. Rapid cooling from the transformation temperature promotes graphite formation, and this helps to explain the susceptibility to graphitisation of the marginal region of welded joints. The use of austenitic electrodes delays graphitisation (because carbon from this region diffuses into the austenitic weld), but does not confer immunity. Plastic deformation and mechanical stressing appear to increase the tendency to graphite formation, which has been observed to occur in prolonged creep tests.

The accelerating effect of nickel (which may be due to the instability of nickel carbide) has been mentioned. That this effect is neutralised by the presence of chromium is shown by the experience of T. N. Armstrong and R. J. Greene,[3] who have given details of an acid open-hearth, nickel-chromium-molybdenum steel slide valve casting, of which the following details were supplied :—

	Per cent
C	0·21
Si	0·39
Mn	0·62
Ni	0·99
Cr	0·61
Mo	0·37

Deoxidised by additions to the ladle of 0·09 per cent calcium-manganese-silicon alloy and 0·12 per cent aluminium.

Annealed 982 deg. Cent., reheated to 843 deg. Cent., and cooled in air, reheated to 650 deg. Cent. and cooled in air.

Welding procedure for pipe ends: preheating to 200 deg. to 300 deg. Cent., welding by metal arc process, and stress relieving at 650 deg. Cent.

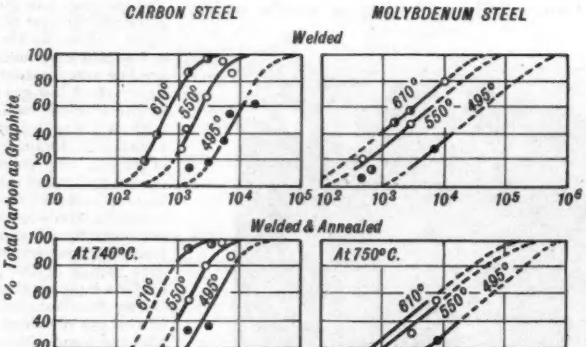


FIG. 2—*Course of Graphite Formation in Carbon Steel and in 0·5 per cent Molybdenum Steel at Different Temperatures Between 495 deg. and 610 deg. Cent. (S. L. Hoyt and A. M. Hall)*

This steel casting gave good service and on dismantling after six years showed no loss of strength, no embrittlement and no graphitisation. It has been in continuous operation for 53,810 hours at an average pressure of 841 lb per square inch, and at temperatures of 855 deg. to 935 deg. Fah., the temperature for 90 per cent of the time being within the range 885 deg. to 900 deg. Fah. (473 deg. to 482 deg. Cent.).

The exact mechanism of the influence of aluminium is not yet clearly understood, but recent contributors[4] to the subject seem to be agreed that the important factor was the effect of aluminium in the nucleation process, and that the role of aluminium in promoting susceptibility to graphitisation is played by the residual aluminium and not by alumina or other products of deoxidation.

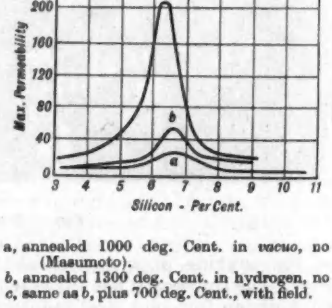
Reference is made in the review[1] to the fact that the graphitisation of steam pipes has not been a serious problem in Germany, and this is attributed to the use in that country of chromium-molybdenum steels to an important extent and to the fact that, in consideration of their effect of creep resistance, high additions of aluminium to the melt have been avoided. Though the addition of chromium to carbon-molybdenum steels is the most effective practical safeguard against graphite formation, some graphitisation has been observed in laboratory samples of 0·5 per cent chromium-molybdenum steels after 20,000 hours at 550 deg. Cent. The carbon and chromium contents require careful adjustment to ensure at the same time that the tendency to graphitisation is suppressed and that good welding properties are preserved. Creep resistance and graphitising tendencies of chromium-molybdenum steels are being studied further.[2]

[1] H. J. Wiester, *Archiv für das Eisenhüttenwesen*, May–June, 1951, Vol. 22, page 177.
[2] N. A. Ziegler, W. L. Meinhart and J. R. Goldsmith, "Trans.," Amer. Soc. Metals, 1950, Vol. 42, page 175.
[3] "Trans.," Amer. Soc. Mech. Engrs., August, 1951, Vol. 73, page 751.
[4] G. V. Smith, J. A. MacMillan, and E. J. Dulis, Amer. Soc. Metals, October, 1950, Preprint No. 17; A. M. Hall and E. Fletcher, "Trans.," A.S.M.E., August, 1951, Vol. 73, page 743.

Magnetic Properties of Iron-Silicon Alloys

METHODS have been developed during the last ten years for cold rolling and heat-treating iron-silicon alloys so as to obtain sheet in which most of the grains lie with the cube edge [100] parallel to the direction of rolling. Compared with ordinary, hot-rolled silicon-iron ("Stalloy"), this anisotropic, highly oriented 3–3½ silicon-iron (known as "Crystalloy" or "Hipersil") has much lower overall energy losses when subjected to alternating magnetisation. By its use, a flux density is obtainable of the order of 30 per cent higher than for the normal hot-rolled sheets. By combining a refining process with the treatment giving the desired rolling texture, an all-round improvement in magnetic properties may be obtained in material magnetised in the direction of rolling.

In a contribution entitled "Iron-Silicon Alloys Heat-Treated in a Magnetic Field" from the Bell Telephone Laboratories, New Jersey, U.S.A., Matilda Goertz[4] describes experiments revealing the possibility of an enormous advance in the values for permeability and for hysteresis losses hitherto reported. Specimens containing 3 to 10 per cent of silicon



Curve *a*, annealed 1000 deg. Cent. in *vacuo*, no field (Masumoto).
b, annealed 1300 deg. Cent. in hydrogen, no field.
c, same as *b*, plus 700 deg. Cent., with field.

FIG. 1—*Effect of a Magnetic Anneal on the Maximum Permeability of Iron-Silicon Alloys (Goertz)*

were made by melting electrolytic iron in a quartz crucible in a high-frequency induction furnace in an atmosphere of helium, adding the silicon, and casting into the form of a ring. The most satisfactory treatment was annealing at 1300 deg. Cent. for 100–120 hours, cooling in the furnace, then heating at 700 deg. Cent. for one hour in a magnetic field of 10 oersteds, followed by slow cooling in the magnetic field. Preliminary annealing at 1000 deg. Cent. was less effective, but confirmed the earlier results of Masumoto. The influence of heat-treatment in a magnetic field on the permeability was

[4] *Journal Applied Physics*, July, 1951, Vol. 22, page 964.

clearly evident over the whole range of silicon contents, but it showed to an outstanding degree in the 6·4 per cent silicon alloy which showed a peak value of over 200,000. In Fig. 1, curve *a* shows the results obtained by Masumoto on specimens, vacuum annealed at 1000 deg. Cent. for one hour and furnace cooled without any applied magnetic field; curve *b* shows the results obtained by the author of the paper on specimens annealed at 1300 deg. Cent. for 120 hours and cooled in the furnace, and curve *c* gives the results after a subsequent annealing at 700 deg. Cent. for one hour in a magnetic field of 10 oersteds and cooling in the field. In further work in the Bell Telephone Laboratories the peak value of maximum permeability has been raised to 500,000 at about 6·8 per cent of silicon, by using extremely pure iron and silicon, and subjecting the alloys to a higher temperature in hydrogen before annealing at 700 deg. Cent. in a magnetic field of 12 oersteds.

Parallel results were obtained by K. Mihara

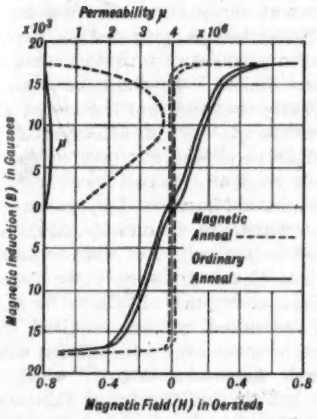


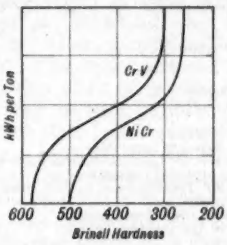
Fig. 2—*Hysteresis Loop and Permeability Curve Before and After Magnetic Anneal of a Single Crystal of 6·5 per cent Silicon-Iron Alloy (Goertz)*

in Japan during the world war. He found that magnetic annealing increased the maximum permeability of alloys up to a silicon content of 6·2 per cent, which was the highest silicon content that he examined. He also found that the hysteresis loop of the 5 per cent silicon alloy had vertical sides after magnetic annealing. This effect was shown even more clearly in further work at the Bell Laboratories, described in this paper. A single crystal of the 6·5 per cent silicon-iron alloy was investigated in the form of a hollow rectangle having each side parallel to the cube edge [100], the direction of easy magnetisation. The maximum permeability of this before magnetic heat-treatment was 50,000; after heat-treatment in a magnetic field it was 3,800,000, the highest value yet obtained with any material (Fig. 2). Subsequent treatment at 650 deg. Cent. in zero field resulted in a loop similar to that obtained before the magnetic anneal.

The significance of the composition 6·4 per cent silicon in relation to peak values is not yet fully appreciated, though it is known to be the composition giving about zero magnetostriction, and nearly that at which atomic ordering begins to be detectable by X-rays. It is clear, however, that at present such a high percentage of silicon can only be used for special purposes. Brittleness, imparted by silicon limits the amount in practice to about 4·5 per cent for hot rolling, and 3·5 per cent for processes involving cold reduction. Unless ductility can be greatly improved, the 6 per cent alloys can only be used in the cast condition.

Induction Heating for Annealing and Tempering Steel

In connection with proposals for hardening steel from the rolling temperature, induction heating for the tempering of steel bars was favourably referred to by H. Krainer* as a process which, within definite limits, offered technical advantages and presumably economic advantages also. However, it necessitated the use of a costly transformer and the installation was therefore likely to be expensive. In order to avoid this relatively costly piece of equipment, trials were put in hand to ascertain whether the inductive tempering and annealing of steel rod could be carried out with grid frequency. Shortly before the end of the war, Brown, Boveri and Co., of Kehlheim, completed the erection of an apparatus operated with grid frequency. Though part of the equipment (viz., the quenching apparatus) was not available for use, the remainder of the

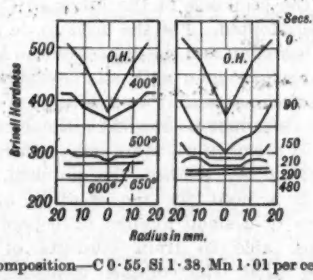


Composition—Cr-V C 0·39, Cr 2·31, V 0·09 per cent.
Ni-Cr: C 0·31, Cr 0·92, Ni 3·64 per cent.

Fig. 1—*Consumption of Energy per Ton of Bar Steel of 40mm Diameter in Tempering Oil-Hardened Cr-V and Ni-Cr Steel to Different Hardness Values (Krainer, Kroneis and Raidl)*

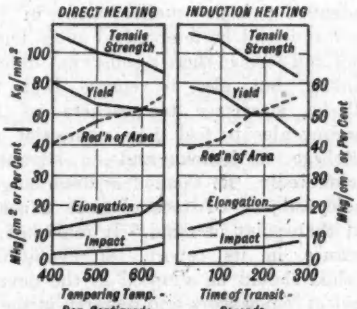
installation was put into service on an experimental basis, and experience of the process has been described by H. Krainer, M. Kroneis and F. Raidl.†

The equipment was operated by current at 500V and was designed for an output of 300kW. At this maximum working power, 1 to 2 tons of steel rod or bar could be passed through per hour. Trials were made with eight different carbon, silicon-manganese, nickel-chromium



Composition—C 0·55, Si 1·38, Mn 1·01 per cent.

Fig. 2—*Hardness Over Cross Section of 40mm Diameter Silicon-Manganese Steel Bar Oil Hardened from 830 deg. Cent. and Tempered for One Hour at Different Temperatures, or by Induction Heating with Different Times of Transit Through the Apparatus (Krainer, Kroneis and Raidl)*



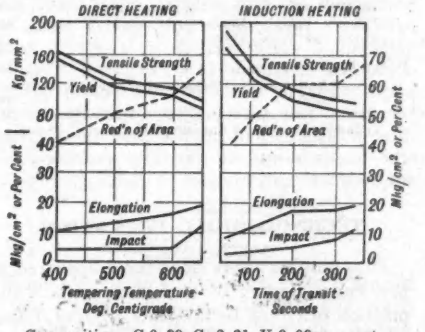
Composition—C 0·62, Si 0·30, Mn 0·59 per cent.
Tests from middle of bar.

Fig. 3—*Mechanical Properties of 40mm Diameter Carbon Steel Bar, Oil Hardened from 830 deg. Cent., and Tempered by the Usual Method for One Hour, or by Induction heating with Different Times of Transit Through the Apparatus (Krainer, Kroneis and Raidl)*

and chromium-vanadium steels in the form of rods of 20mm to 60mm diameter. The rate of working and the efficiency of the equipment was very dependent on the dimensions of the bars and the ferromagnetic properties of the steel. The range of 32mm to 56mm was too wide; the best results were obtained with 40mm diameter bars. The rate of working naturally also depends on the temperature required in the bars; the higher the temperature, the greater will be the energy consumption per ton of steel and the lower the rate of working. This is illustrated in Fig. 1.

The annealing of cold-worked steel was carried out satisfactorily. An advantage of the method was the slight, almost non-existent scaling, which could be further reduced by the use of a protective atmosphere. The equipment was not suitable for the full annealing of steels (especially alloy steels) in the as-rolled or hardened condition. On the contrary, satisfactory results were attained in tempering hardened steels, especially in the medium and high grades of tensile strength.

Only the alloy steels showed uniform hardness throughout the section in the oil-hardened condition; others were considerably harder at the outside than at the centre. The hardness gradient from outside to centre of the bar was



Composition—C 0·39, Cr 2·31, V 0·09 per cent.
Tests from middle of bar.

Fig. 4—*Mechanical Properties of 40mm Diameter Chromium-Vanadium Steel Bar, Oil Hardened from 830 deg. Cent. and Tempered by the Usual Method for One Hour, or by Induction Heating with Different Times of Transit Through the Apparatus (Krainer, Kroneis and Raidl)*

rather greater after induction heating than after ordinary tempering at low temperatures, but uniformity throughout the section resulted from higher tempering temperatures which were attained by slowing down the rate of transit of the bar through the induction heating apparatus (Fig. 2). Figs. 3 and 4 show the mechanical properties of a carbon steel and a chromium-vanadium steel tempered after oil hardening by ordinary heating and by induction heating. Judged on the basis of equal tensile strengths shown by tests taken at the centre of the bar, the other properties were independent of the method of tempering, and were similar whether direct heating or induction heating was employed.

The comparative merits of induction heating and resistance heating as rapid methods of tempering were raised in the discussion. In the opinion of the authors, resistance heating was to be preferred for thin material. With thicker dimensions there was a very high current consumption which necessitated the use of a single-phase transformer. Apart from other objections, this would make the equipment dearer than the grid-frequency induction equipment. The two processes would have to run side by side with the more ordinary methods of tempering, and in the course of time each process would find its most appropriate field of usefulness.

Vegetable and Animal Oil Processing Plant.—The Power-Gas Corporation, Ltd., Stockton-on-Tees, has issued a booklet describing the company's hydrogenation process, the purpose of which is to raise the melting point of a liquid oil to render it suitable for the manufacture of an edible or technical fat. This is done by the oil absorbing hydrogen gas by a catalytic reaction at a regulated temperature and pressure. The booklet discusses the basic chemical aspects, the production of hydrogen, the preparation of the catalyst, refining and the hardening process, which is illustrated diagrammatically. An appendix tabulates the cubic feet of electrolytic hydrogen required per ton of a number of oils.

* *Stahl und Eisen*, 1945, Vol. 65, page 95.

† *Stahl und Eisen*, August 16, 1951, Vol. 71, page 880.

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Vol. CXCII SEPTEMBER 28, 1951 No. 4992

Contents

PAGE

LEADING ARTICLES—
Technological Education ... 400
Turbine Locomotives ... 400

SPECIAL ARTICLES—
Engineering and Marine Exhibition. No. V. (Illus.) 403
Grand Coulee Pumping Plant, Coulee Dam, Washington. No. II. (Illus.) ... 386
Iron and Steel Institute in Austria. No. I. (Illus.) ... 394
Paris Machine Tool Exhibition. No. II. (Illus.) ... 390
S.B.A.C. Flying Display and Exhibition. No. III ... 392
Cleaning and Sealing Joints in Concrete Roads. (Illus.) 408
Electricity Failure in N.W. England ... 404
Levelling Machine. (Illus.) ... 411
Modern Developments in Reinforced Concrete Design. (Illus.) ... 409
Oil Refinery at Fawley No. II. (Illus.) ... 405
Pressure Relay. (Illus.) ... 408
Turret Jaw Vices. (Illus.) ... 412

METALLURGICAL TOPICS— ... 398
Graphitisation in Heat-Resisting Molybdenum Steel. (Illus.) ... 398
Magnetic Properties of Iron-Silicon Alloys. (Illus.) ... 398
Induction Heating for Annealing and Tempering Steel (Illus.) ... 399

PAGE

LETTERS TO THE EDITOR—
Return of the Native ... 402
Closing of Branch Lines ... 402
Locomotive Boilers ... 402

LITERATURE ... 401
Books Received ... 402

OBITUARY—
Fred Clements ... 401
Sir Henry T. Holloway ... 401

A SEVEN-DAY JOURNAL ... 385
Chemical Research Laboratory
Derailment of the Liverpool-Euston Express
Discussion on Metal Economics
Productivity Team Report on the Brass Foundry Industry
Progress of Harlow New Town
Science and the Building Industry

NEWS AND NOTES—
British Patent Specifications. (Illus.) ... 415
Catalogues ... 416
Forthcoming Engagements ... 416
French Engineering News ... 412
Industrial and Labour Notes ... 413
Notes and Memoranda ... 414
Personal and Business ... 414
Technical Reports ... 397

TECHNOLOGICAL EDUCATION

IT is now six years since there appeared in the Percy Report of 1945 the words, "the position of Great Britain as a leading industrial nation is being endangered by failure to secure the fullest possible application of science to industry and this failure is partly due to deficiencies in education." Since then, the number of students attending universities in technological subjects has doubled by comparison with pre-war figures, and a number of universities have started post-graduate courses in technology. But throughout that period it has been recognised that provision should also be made for a form of academic training in technology that the universities are not well-fitted to provide. No action has, however, been taken. Until last week the matter had only been discussed. Then, just before it was announced that a General Election would be held on October 25th, the Government issued a white paper on "Higher Technological Education," in which it announced its acceptance, in general, of the recommendations of the National Advisory Council on Education for Industry and Commerce in a report that body issued in November last year. It was there suggested, it will be remembered, that a "Royal College of Technologists" should be set up to encourage the development in suitable technical colleges of advanced courses at "first award" and "post-graduate" levels, that increased financial assistance should be given to the colleges and that new courses should be developed in close association with industry. Under the terms of the white paper, the Government has decided, for the present, to drop the term "Royal" from the title of the proposed new body; and it is proposed to establish the College without, "at the first stage at any rate," any responsibilities other than the granting of awards and the approval of courses. Those are wise decisions. For the original proposals of the Advisory Council gave rise to a suspicion that an unreasonable attempt was to be made to set up by decree a new professional technical society intended to have, in relation to existing professional technical bodies, much the same status that the Royal Society has earned in relation to other scientific bodies by centuries of work.

It seems probable, whatever the complexion of the Government that comes into power next month, that a scheme at least based upon the proposals of the Advisory Council will be adopted. For the need to do something is urgent, and the discussion can hardly be re-opened again with all the delay that would then necessarily be involved. Yet the proposals cannot be studied without misgivings. It seems to us, as to many others who have seriously studied the problem, that there is a need for the creation in this country of a small number of technological colleges, able to train students of such quality that the colleges concerned will gain, in time, international reputations as high as those, for instance, of the Massachusetts Institute or the Zurich Hochschule. Those colleges need to attain such reputations not only in order to attract students of high quality who, in their absence, would be tempted to enter universities and receive there a somewhat different training, but also to ensure that they will be attractive to teachers of high standing able to feel their connection with a college an honour and an advantage. Undoubtedly, the Council in discussing the whole subject of technological education had that point in mind. It remarked, for instance, in its report, "an evolutionary method should be adopted in the development of higher work and research in the colleges, whereby advanced courses are concentrated, as speedily as building conditions permit, in colleges which are in a position to transfer elsewhere the whole, or the greater part, of their junior and less advanced work." And again "conditions in the colleges should be such as will attract good students and the right kind of staff." Furthermore, references are made to "adequate equipment and opportunities for research, and salaries appropriate to the type of work being done." But it is left unclear in the report whether selected colleges should be given that freedom that government by their own governing bodies implies. Also, the proposals of the Council leave it unclear as to how a few colleges are to be selected from the many for the preferential financial treatment that should be, but does not very clearly seem to be, envisaged.

The acceptance of the report by the Government thus still leaves a good deal obscure. In the white paper the proposal that has been under discussion ever since the issue of the Percy Report for the setting up of one or more technological "universities" is rejected on the grounds of its cost, estimated at £6 million, the time it would take to plan, build and equip one, and the diversion of resources "which are urgently needed elsewhere." It may be assumed, therefore, that the amount of finance that the present Government, if not a new one next November, is prepared to devote to the encouragement of technical colleges will be very limited. In those circumstances, it is clearly essential that the money should not be frittered away in an attempt to improve conditions in all the sixty-six colleges that exist in England, Scotland and Wales. A very few should be selected, by reason of their present repute or favourable situation, to receive the lion's share of what is available. According to the Advisory Council's report "The actual selection of colleges for the particular advanced courses required should, we feel, be made after consultation with the Regional Academic Boards, which were established by the Ministry of Education to give advice in the field of technology." But there are ten such boards, and we cannot but feel that there will be, first, competition amongst them in favour of colleges in their own areas, and secondly, a disinclination, too, to be ruthless in favouring a particular college as against others in a single area. It is, indeed, unclear in the report and in the white paper, what bodies, the Government, the new College of Technologists—the constitution of whose governing body does not seem suited to ruthless decisions—or the Regional Boards, are to be mainly responsible for selecting or advising upon the selection of the very few colleges—it should be no more than five or six, in our view—which are to receive preferential treatment. The Government, according to the white paper, is to announce soon its proposals for making improved financial assistance available. We shall study those proposals with interest. For they may make clear what the report itself left obscure.

TURBINE LOCOMOTIVES

THE decision reached by the Railway Executive to reconstruct as a four-cylinder engine of the "Princess Royal" type, the turbine locomotive No. 6202 of the former London, Midland and Scottish Railway, noted in our issue of June 18th last, brings to a close a locomotive experiment of much interest. Built in 1935 to meet the requirements of Sir W. Stanier, this turbine engine ran in all some 400,000 miles in main line passenger services, with, it would seem, a considerable measure of success, but, though carefully conceived and constructed from the standpoint of maintenance costs and reliability, it has not quite fulfilled expectations and in this respect compared

unfavourably with similar four-cylinder engines of equal capacity.

In theory, the turbine drive has everything to commend it. With it the transmission of power is purely rotary. The tractive effort and drawbar pull are, therefore, for any power output, constant throughout each revolution. Further, the drive between the turbine and the locomotive axles is totally enclosed and self-lubricating. There is, therefore, an entire absence of disturbance due to reciprocating parts, characteristic of locomotives of normal design, combined with a mechanism working under ideal conditions. From the point of view of thermal efficiency, a turbine might be expected to utilise high pressure superheated steam to much more advantage than is possible with simple expansion cylinders. In other words, the heat utilised for each pound of steam delivered to the turbine should be increased and efficiency thereby improved, thus resulting in a marked economy in the fuel used for the work done. Actually it would seem the mechanical parts of the turbine drive have not given the standard of performance expected, while the fuel consumption obtained in relation to the power developed, though satisfactory, has not proved to be materially better than is attained with the corresponding four-cylinder engines. Here, then, is an example of theoretical considerations, well founded in themselves, being entirely contradicted by actual practical experience. It contrasts with the great success that has attended the use of the steam turbine for the generating of electricity and for marine purposes.

In the turbine locomotive as built for the former L.M.S. Railway, we have seen one of the most painstaking and thorough trials ever carried out on our railways with a new form of prime mover. Mr. R. C. Bond's paper, read before the Institution of Locomotive Engineers in 1946, conclusively proves this to be the case. It would therefore appear that, while steam is used, the reciprocating engine still retains its place. So far as the non-condensing steam turbine locomotive is concerned, the lengthy and no doubt costly experiment made by the former L.M.S. Railway has been fully justified on account of the comprehensive manner with which it was conceived and carried out, so leading to the conclusion that "sufficient knowledge of the capabilities of this type of propulsion on railways has been obtained over the years this locomotive has been in service." Whether or not the experience gained would allow of the construction of a really successful turbine-driven locomotive we do not know. Judging, however, from results obtained with other locomotives of this type, it seems clear that the difficulties encountered with the turbine and its attendant power transmission gears have not yet been successfully overcome.

Obituary

FRED CLEMENTS

MR. FRED CLEMENTS was a well-known engineer in the British iron and steel industry and his death, which occurred suddenly at Eastbourne, on Wednesday, September 19th, at the age of sixty-nine, will be deeply regretted. Until his retirement at the end of 1946, Mr. Clements was chairman and managing director of Park Gate Iron and Steel Company, Ltd., in the service of which firm he spent nearly the whole of his working life.

Fred Clements was born at Whittington, Chesterfield, on January 4, 1882, and received his general education at Dronfield Grammar School. Subsequently he studied at Chesterfield Technical School and in the evening classes at Sheffield University, gaining a Whitworth Exhibition in 1905. His practical training began in 1896, when he was apprenticed to Markham and Co., Ltd., Chesterfield. After completing his apprenticeship, Mr. Clements continued for a time in the drawing office of Markham and Co., Ltd., and then, in 1903, entered the drawing office of Park Gate Iron and Steel Company, Ltd. Three years later he became chief draughtsman and was subsequently promoted to the positions of engineer and general manager of the company. Mr. Clements was elected a director of the Park Gate Company in 1935, succeeding shortly afterwards to the offices of managing director and chairman. Under his able guidance many developments were successfully undertaken at Park Gate, and in his earlier years there, Mr. Clements was responsible for the design and installation of a considerable quantity of new plant.

During the first world war Mr. Clements, in addition to his arduous work at Park Gate, served as honorary consultant to the Department of Explosive Supplies and was closely associated with the work of the explosives factories at Queensferry and Gretna. At one time he also lectured on heat engines at the Chesterfield Technical School. Mr. Clements was a valued member of the Iron and Steel Institute, which he joined in 1920. He was elected to the Council in 1930, becoming a vice-president in 1940 and an honorary vice-president on his retirement in 1946. He contributed several papers to the proceedings of the Institute and, in 1936, was awarded the Bessemer Gold Medal—the Iron and Steel Institute's highest honour—for meritorious services to the iron and steel industry. In making the presentation, special mention was given to Mr. Clements' book on "Blast Furnace Practice," which was published in 1929. Mr. Clements was also a member of the Institution of Civil Engineers and the Institution of Mechanical Engineers, and an Associate Member of the Institution of Electrical Engineers.

Fred Clements had many friends in the engineering and iron and steel industries of this country, who will mourn his death. In the responsible positions he so ably occupied with the firm which he served for over forty years, it was his endeavour to create an organisation in which each member should feel encouraged to contribute his quota of original thought and effort for the welfare of the firm and of the iron and steel industry generally.

SIR HENRY T. HOLLOWAY

WE record, with great regret, the death of Sir Henry T. Holloway, which occurred in London on Tuesday, September 18th. Sir Henry had a very long association with Wiltshire and particularly with West Lavington, where he succeeded his father, the late Henry Thomas Holloway, as the owner of the West Lavington Estate.

Sir Henry was born in 1876 and joined the firm of Holloway Brothers (now Holloway Brothers (London), Ltd.) in 1893, the firm having been founded by his father and his uncle some eleven years previously. In his early years of service with the firm he was actively engaged in building operations and gained the experience which stood him so well in later life and enabled him to hold with ability and dignity the positions which he ultimately attained.

Sir Henry was first appointed a director of the firm in 1912, upon its incorporation. With the death of his uncle, in 1923, he was appointed a managing director of the company and became chairman ten years later, on the retirement of Mr. Samuel Holloway in 1933, a position which he held until his death. He was thus directly associated with and largely responsible for the achievement of the reputation which his company now holds.

Notwithstanding his many activities, Sir Henry found time to associate himself with the work of many organisations and at various times he held the presidency of the London Master Builders' Association, the Institute of Builders and the Federation of Civil Engineering Contractors. He was also a chairman of the Joint Uniformity Board. Recognition of his ability and of his many public services came in 1945, when the honour of knighthood was conferred upon him, particularly in connection with his wartime activities as president of the Federation of Civil Engineering Contractors.

Literature

World Geography of Petroleum. By WALLACE E. PRATT. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 48s.

THIS publication presents a survey of the world's petroleum from a new angle and one which is of absorbing interest.

Technically, there is little new in its pages and this is not its mission. It first seeks to co-ordinate the work of the geologist and the geographer, and then, through geography, to survey the political aspects of the distribution of petroleum and its economic and strategic value throughout the world. It has been compiled under the capable editorship of Dorothy Good, of the American Geographical Society, and the list of contributors includes names which are famous throughout the petroleum industry.

Leading this distinguished gathering and sharing the editorship is Mr. Wallace E. Pratt, who, as a geologist and vice-president of the Standard Oil Company, of New Jersey, has for many years been recognised as one of America's foremost petroleum authorities. Mr. Pratt, in his introductory preface, makes the significant statement that the natural distribution of petroleum is admirably suited to man's needs and that in a free and peaceful world its equitable distribution offers no formidable problem. In a world of conflict, however, the control of these resources becomes the object of vital military strategy. He adds that the most formidable barriers to development of the earth's petroleum resources lie in the restrictions of exploratory activity which have grown out of recent nationalisation policies of many Governments. These remarks provide a fitting introduction to some of the more interesting sections of the book.

The familiar subjects of geological principles, exploration, development, production, storage and distribution are briefly but adequately dealt with in two short chapters. There follows a comprehensive survey of the world's petroleum regions divided into fifteen different areas. Each of these areas is dealt with separately by a writer who is a world authority on the particular region. In this section not only is the early history of petroleum recorded in a very readable form,

but many interesting descriptions are given of the climatic conditions, the type of country, the life of the people and their reactions to the impact of the discoveries of petroleum on their country; in relation to some of these countries important notes are included on the political background. Those sections embracing the Middle East, by Dr. G. M. Lees, and Saudi Arabia, by Messrs. Max Steineke and M. P. Yackel, are of particular interest to people in this country.

Two regions covered in this section have the peculiar interest that their petroleum resources are undeveloped. These surveys, of the Polar Regions and the Continental Shelves, were contributed by Mr. Wallace Pratt. On what is for him familiar ground, Mr. Pratt discusses the possibilities of future petroleum reserves being drawn from these inaccessible regions. In the search for oil on the continental shelves of North America the author has played a great part and he has much information to impart.

The fourth section of the volume is entitled "Aspects of Utilisation." It is of interest chiefly to the economist, the strategist and the politician. In this section the picture presented is an entirely new one in petroleum literature, in that it discusses its utilisation both in peace and in war. In the chapters devoted to peace an interesting survey is presented, illustrated by diagrams purporting to show the energy output per man in various countries related to the type of fuel predominantly utilised in that country. The date of these figures is 1938. Though the survey gives the overall impression that statistics, properly handled, can, as is so often claimed, "prove anything," so enlightening are the results obtained that one can only hope that they will be brought up to date. Until they are, comment must be reserved.

The final chapter of the book, "The Effect of the World's Distribution of Petroleum on the Power and Policy of Nations," is as arresting as its title. The author, Mr. Herbert Feis, of the U.S. State Department, here outlines a policy designed to maintain world peace by a broad control of petroleum, which, presented from the American angle, is of some interest. There is much food for thought in this chapter and much also that is controversial. In the light of recent petroleum politics, one component of the author's "peace" policy is worthy of quotation. He states: "Should it prove necessary, and in such a way as at the time may be judged feasible, armed protection should be given in the event of an attempt to dispossess these United States enterprises (oil enterprises abroad) by force. Such a contingency is possible in the near future in the Middle East." The reader must form his own judgment as to the wisdom of such a policy.

The book is a remarkable collection of the very latest thought on petroleum matters, and even though some of that thought is controversial, the book is none the worse for its inclusion. It does need to be remembered, however, that the views expressed are the views of late 1949 and early 1950. Since then much has happened!

The illustrations, maps, diagrams and photographs, like all those that appear in American Geographical Society publications, are superb.

INSTITUTION OF CHEMICAL ENGINEERS.—Since 1923, the Institution of Chemical Engineers has published its "Transactions" in annual volumes. In order, however, to reduce the interval between the presentation of papers and the issue of the "Transactions," it has now been decided to publish the latter in quarterly parts. The first of these, numbered Part I, Volume 29, 1951, has just appeared.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE RETURN OF THE NATIVE

SIR,—Mr. Carty's letter in THE ENGINEER of September 7th, has been read by me with both pleasure and profit, particularly the latter, as he makes it quite clear to me that I arrived in England cumbered by certain misapprehensions that are likely to get me into trouble—have already done so, in fact. These Mr. Carty's able clarification has dissipated, once and for all.

First, that corridor. In my transatlantic stupidity I thought a corridor was primarily a passage, a thoroughfare, provided to allow more or less easy transposition of bodies, human or otherwise, from point to point. For instance, in railway carriages it allows the traveller to move from compartment to diner, or maybe to another bourne. That was what I thought; but now, thanks to Mr. Carty's able exposition, it is evident I was wrong and my complaints out of place. I gather the corridor is not provided for any such purpose—at any rate, on British Railways. It is intended to be (1) a baggage-van; (2) a dormitory; (3) an "overflow" depository; any resemblance it may have to a corridor or passage is purely coincidental. So—thanks to Mr. Carty—the next time I travel by train on British Railways I shall sit corrected, or more probably stand corrected, in the so-called corridor, together with my baggage; in the place specially provided for us both, and for all individuals who recklessly begin a journey upon British Railways unprovided with a shoehorn, without which penetration into a compartment is generally impossible. So that's off my mind.

Second, the luggage-van: I must have had delusions about this, too, if my gentle chidings are objected to. Evidently this vehicle is not provided for suitcases—the corridor is the proper place for them. When I, with the best of intentions, put my two in the van at St. Pancras, there were only two other items of baggage in that whole vast, empty, echoing void—then there were four. When I got to Sheffield there were none; they had all been dumped off at Bedford. I see now it just served me right; I should have put them in the corridor for safety, as a trap for the unwary and an exasperation to the hasty, or for anyone navigating the narrow channel upon their lawful or sanitary occasions. Then I shouldn't have lost them—my mistake again.

Third: cinders and soot. No, Mr. Livesay is not afraid of either; in fact he loves them and is never happier than on finding himself where they are most in evidence—at locomotive sheds, for example, where under present conditions they are forced upon one's notice and it is impossible to avoid them. Goggles, too, he does wear on occasion, and self-provided, he having conscientious objections, as a mere visitor, for applying to the National Health Service for these safeguards. Apparently drivers and firemen have similar scruples, because he has yet to see an engineman wearing them. But with regard to cinders and soot, with the utmost deference and respect to Mr. Carty's views, Mr. Livesay is of the opinion that there is a place for everything, and that the footplate, in front of the smokebox door, is not the place for these carboniferous deposits—even in a Welfare State. Neither would Mr Livesay "prefer to be coated from head to foot with very fine soot," and he sees no reason to anticipate this, after travelling tens of thousands of miles on oil-fuelled locomotives and behind them, without noticing the slightest evidence of soot on any part of his anatomy or apparel—that, of course, was in North America, not France. He can only infer that the particular American locomotive, behind which Mr. Carty was unfortunate enough to travel, needed shopping, or that there was a peculiarly mutton-headed fireman persecuting his vocation in the cab.

Fourth, and not to be outdone by Mr. Carty, may I respectfully inquire whether he is aware that there are milestones on the Dover Road? If he should query what this has to do with points raised in my original letter, I can only reply—"Nothing—it comes into the same category as the 'Mistral' train." British trains, not French, were under review; Mr. Livesay knows nothing of the latter. Here again he profits from Mr. Carty's dissertation; when he crosses the Channel he will, thanks to Mr. Carty's terrifying description of the conditions to be met with upon it, avoid "Le Mistral" as the plague.

Finally, may I conclude—again quoting Mr. Carty—by respectfully inquiring whether he is aware that though "there is a peace on," we are all busily engaged preparing against the possibility of still another bigger and better war? Because, if so, and if my gentle chiding of British trains was out of place and in bad taste—after all, I am English, not Canadian, and so still have a right to say what I think in my own much-loved country—why Mr. Carty's blistering criticism, apropos of nothing I said, of "Le Mistral"? Are not the French also busily preparing against the possibility of still another bigger and better war? Because, if they aren't, God help us!

EDWARD H. LIVESAY

Edgware, Middlesex, September 11th.

THE CLOSING OF BRANCH LINES

SIR,—Mr. S. T. Saunders has raised a most important point in his letter of August 21st, published in your issue for September 7th, in his reference to the necessity for provision of means of transport of luggage, perambulators, dogs, &c., for people who cannot afford taxis or cars. This is something for which the bus services do not cater (except in the case of dogs on some country routes) and is, I think, a matter which has been consistently overlooked. Mr. Saunders's excellent suggestion merits the most serious consideration.

C. FRANCIS-CARTER

Swansea, September 15th.

LOCOMOTIVE BOILERS

SIR,—Can any of your readers tell me what is the amount of the saving given by the tapered boiler of the old G.W.R. and L.M.S. It ought to be appreciable to compensate for the more awkward job of production.

J. H. H. GOODALL

Yorkshire, September 20th.

BOOKS RECEIVED

Handbuch der Werften, 1950. Hamburg: Schiffahrts-Verlag "Hansa," C. Schroedter and Co., Hamburg, 11.

Gas Journal Calendar and Directory, 1951. London: Walter King, Ltd., 11, Bolt Court, Fleet Street, E.C.4. Price 25s.

Domestic Water Heating. By Ronald Grierson. London: Iliffe and Sons, Ltd., Dorset House, Stanford Street, S.E.1. Price 25s.

Chemical Engineering Operations. By Frank Rumford. London: Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 30s.

Physics. By S. G. Starling and A. J. Woodall. London: Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 42s.

Mechanism of the Watch. By J. Swinburne. London: N. A. G. Press, Ltd., 226, Latymer Court Hammersmith, W.6. Price 10s. 6d.

Elements of Soil Mechanics in Theory and Practice. Kelvin Ll. Nash. London: Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 9s.

The Engineering and Marine Exhibition

No. V—(*Continued from page 362, September 21st*)

WE conclude in this issue our account of the plant and equipment which was to be seen at the recent Engineering, Marine and Welding Exhibition at Olympia.

Kelvin and Hughes, Ltd.

Two developments of interest to the welding industry and to users of welded equipment were included in the exhibits shown by Kelvin and Hughes, Ltd.

The first of these developments concerns the investigation of resistance welding by the company's recording apparatus, consisting of amplifiers operating high-speed pen recorders. This technique was the subject of demonstrations arranged to show a method of direct recording, on chemically treated paper, four of the more important quantities affecting the quality of a weld—that is, the current, the voltage, the force on the electrodes, and the welding time. The pen recorder used for this demonstration has a frequency response which is flat, within 6 per cent, from 0 to 90 c/s, with a pen amplitude of $\pm 7{\cdot}5$mm, making it suitable for most applications of resistance welding.

Briefly, the arrangements are as follows.

Current measurements are made on the output side of the welding transformer, one of the electrodes carrying full secondary current being passed through the middle of a "toroidal" pick-up coil. The output from this coil is fed into the input of one of the channels of a Kelvin Hughes amplifier (type 2). This amplifier is a four-channel d.c. unit giving full-scale deflection for approximately 3V.

The working voltage is measured directly across the electrodes and fed into one of the channels of the amplifier and thence to the four-channel recorder. The duration of the welding operation is indicated by a micro-switch affixed to the foot control which is coupled directly to the fourth pen of the recorder. Mechanical pressure or the force acting on the electrodes is converted into strain in a diaphragm, the strain being measured by using resistance strain gauges and the Kelvin Hughes single-channel amplifier unit, which consists basically of an a.c. bridge, an a.c. amplifier, demodulator and d.c. amplifier.

The second technique associated with welding, demonstrated by Kelvin and Hughes, Ltd., was that of weld testing with the help of the Mark 4 supersonic flaw detector, which is an improved version of the instrument described in our issue of Sept. 16th, 1949. The supersonic detector has been applied to the testing of butt welds and, more recently, flash welds; for fillet weld testing, which has hitherto presented difficulties, 45 deg. transverse wave probes have been used with success to determine degrees of penetration, and the presence of cracks, slag inclusions and porosity.

The company also exhibited a range of "Pneumercator" tank gauges. In its standard form the gauge consists of three parts—a balance chamber, a gauge and a hand pump—which are normally connected together by single lengths of $\frac{1}{4}$in solid-drawn copper tubing. The balance chamber, which is fitted close to the bottom of the tank, is a small hemispherical vessel with a sharp-edged orifice cut near its base which forms the measurement datum level; it has no moving parts and, once fitted, requires no attention. The gauge is a simple, robust mercury manometer, with a control valve at its lower end, and is graduated to read depth, volume or weight. The hand pump is of stout construction and fitted with a bracket for convenience of fixing.

To operate the equipment the control valve at the base of the gauge is moved to an indicated position which connects the pump with the balance chamber. Sufficient air is then pumped through to restore level of liquid in balance chamber to datum level. The control valve is then moved to connect balance chamber with gauge, and a reading is taken. The whole series of operations can be carried out in a few seconds.

For use with large storage tanks, where a small change of liquid depth involves a considerable change in volume of liquid, a precision gauge working on the same principle is available. The instrument is capable of reading to within $\frac{1}{16}$in of depth, whilst, if necessary, this can be extended to $^1/_{32}$in. A third version of the instrument is a distant reading water level gauge for land or marine boilers.

Davey, Paxman and Co., Ltd.

A new engine, manufactured by Davey, Paxman and Co., Ltd., of Colchester, was displayed on the stand of Ruston and Hornsby, Ltd.—a four-cycle, compression ignition, six-cylinder, vee-form unit developing 250 b.h.p. at 1250 r.p.m. Faces on the upper side of the cast iron crankcase carry separate cylinder blocks cast in sets of three bores and arranged in banks set an included angle of 60 deg. Dry cylinder liners are

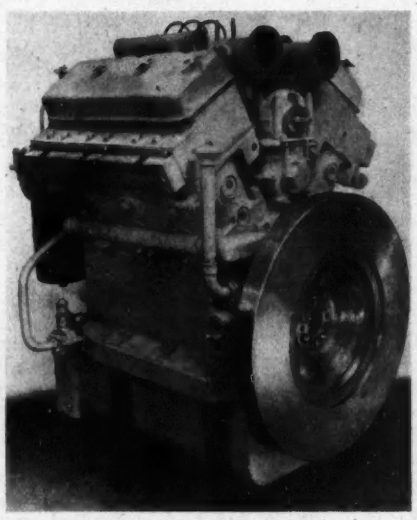


FIG. 47—SIX CYLINDER VEE ENGINE —DAVEY PAXMAN

fitted and a lubricating oil sump of light welded steel encloses the underside of the crankcase. The cylinder heads are of cast iron and in sets of three, they carry the valves and rocker gear and also accommodate the spherical ante-chambers of the Ricardo combustion system.

Low expansion aluminium alloy pistons are fitted and the connecting-rods are machined from steel stampings. A blade and forked construction is employed for the large-end bearing, which has a steel bearing block housing a replaceable shell copper-lead lined bearing operating on the crankpin. The outer surface of the block is chromium-plated to receive the replaceable copper-lead lined bearing of the blade rod. The underslung crankshaft is carried in four copper-lead steel shell bearings and drives through gearing at engine speed a built-in balance shaft fitted with counterweights. The camshaft is located between the cylinder blocks. There is one fuel pump per cylinder, and these pumps which are grouped in a self-contained unit with an integral camshaft deliver at low pressure to single-hole pintle-valve injectors.

A hydraulic servo governor controls the engine at all speeds and two valveless, engine-driven gear pumps, located in the sump, maintain pressure lubrication; one is a pressure pump, while the other is for cooling. Built into the end of the sump is a centrifugal water pump, which is gear-driven from the free end of the engine. Our illustration in Fig. 47 shows the engine without reverse and reduction gear. When fitted this gear is oil operated and incorporates reduction gearing in ratios up to 3 to 1, or is arranged for direct drive.

Welding and Industrial Heating Equipment

Besides the welding plant described in previous instalments of this article, there were a number of other interesting exhibits, which, for reasons of space, can only be mentioned briefly here.

The spot-welding pliers, manufactured and demonstrated by A.R.O. Machinery Company, 18, Madrid Road, London, S.W.13, constitute a useful portable tool for sheet metal work and light fabrication in garages and small workshops. The "pliers" take the form of an electrode holder (measuring 18½in by 4½in by 6⅞in and weighing 22 lb), connected by a four-core cable to a contactor control box, which embodies welding time control from 0·1 sec to 1 sec. Simple adjustments for electrode pressure and electrode gap are incorporated in the welding pliers and the capacity of the equipment is stated to be up to 14 plus 14 S.W.G. steel.

The wide range of resistance welding plant shown by Sciaky Electric Welding Machines, Ltd., Slough, Bucks, included the "RAMU.50" universal, motor-driven, air-operated, seam-welding machine, which has a nominal rating of 50kVA when arranged with arms permitting a working throat depth of 24in and a welding capacity of up to 16 plus 16 gauge mild steel. A range of welding speeds up to 9ft per minute are available and this plant has been designed for the welding of small diameter cylindrical components as well as flat sheets, &c. Weld pulsation control is effected by a Sciaky motor interrupter controlling the firing of ignitron tubes.

Recent progress made by Rockweld, Ltd., Commerce Way, Croydon, Surrey, was typified in the company's "ODR 300" welding generator set. This equipment comprises an Armstrong Siddeley twin-cylinder, air-cooled engine, flexibly coupled to a generator embodying a counter compounding series winding. Control of the welding characteristic is achieved by independent regulation of two separate shunt fields—one giving stepless variation of the welding current between 40A and 300A, and the other giving open circuit voltage control between 55V and 80V. Among the many new electrodes exhibited by the same company was a range of six new ones, known as "Chromac," for stainless and heat-resisting steels.

A 4kW, dual working, radio-frequency induction heating equipment was one of the

interesting exhibits shown by the Industrial Supplies Division of Standard Telephones and Cables, Ltd., Foots Cray, Sidcup, Kent. This unit enables two heating operations to be carried out consecutively so that one workhead can be loaded while the other is being used for the actual operation of soldering, brazing, annealing or hardening. For this class of heat-treatment two examples of the company's new electro-gas equipments were exhibited. In this design of heater normal town's gas supply mixed with compressed air is fed to high intensity burners, to give localised heating, while precise control is exercised by electrical circuits.

S. E. Opperman, Ltd.

A new range of worm reduction gears, geared motor units, and worm gear motorised units was displayed on the stand taken by S. E. Opperman, Ltd., of Boreham Wood, Herts. One of this firm's new "Unifraction" range of single worm reduction gears, which are suitable for use with motors from $^1/_{20}$h.p. to 1 h.p., according to ratio and speed, is illustrated in Fig. 48. These units are made in ratios ranging from 5½ to 1, to 50 to 1, and are particularly compact and robust.

The centre sections of the light alloy cases of the units are spigoted between the combined side and base members and they can be arranged with the input, or worm shaft above or below the output, or wheel shaft, or, alternatively, vertically on the right or

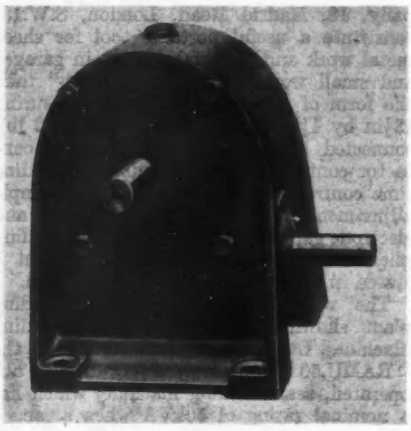


Fig. 48—Single Worm Reduction Gear—Opperman

left side of the output shaft. The bronze worm wheel and the nickel steel worm are both machined to fine limits and are mounted on double-purpose ball bearings.

A right-angle, flange-mounted worm gear motorised unit exhibited was designed for transmitting from 1 h.p. to 2½ h.p., according to the ratio required, and based upon a motor input speed of 1420 r.p.m. It could be fitted with ratios ranging from 5¾ to 1, up to 60 to 1.

A new coaxial geared motor unit is being made by the firm in four sizes from $^1/_{10}$ h.p. to 2 h.p. In these units output speeds ranging from 540 to 12 r.p.m. are obtained by using single, double or triple reduction gear trains, and the same gear case is used for any of the reductions.

In these units the helical gear trains are mounted on ball bearings throughout, and the gears are made from heat-treated, high-tensile steel.

Electrical Instruments and Control Systems

Of the many interesting instruments and control systems seen on various stands a few are briefly referred to in the following paragraphs.

An electronic tachometer, designed for an accuracy of ±1 r.p.m., within the range of 500–10,000 r.p.m., was demonstrated by Pametrada. This instrument is essentially an electronic counter, which gives a reading on an illuminated indicator every two seconds, a period which is long enough to allow each reading to be noted by an observer, and short enough to avoid significant changes of speed in the intervals between readings. The accurate time standard that is necessary to convert the direct count into a rate is provided by a temperature controlled tuning fork, giving a frequency of 1000 c/s, from which the required two-second period is obtained by frequency division. The instrument, which is built in units in a 6ft standard rack, consumes about 650VA at 250V, 50 c/s.

A recently developed "Dionic" meter for determining steam purity by measuring the electrical conductivity was demonstrated by Evershed and Vignoles, Ltd., Acton Lane Works, Chiswick, London, W.4. In this method of measurement the first step is to pass the steam through an Evershed-Straub degassing condenser to remove gases such as ammonia, carbon dioxide or hydrogen sulphide (which would vitiate the conductivity reading). The sample of condensed steam is then passed to the conductivity tube, which is similar in principle to the "Dionic" steam purity meter. It embodies four platinum electrodes, to measure the electrical conductivity, which is proportional to the quantity of inorganic gases and salts dissolved in the steam.

Recent developments in the automatic steering control of ships were demonstrated by the Sperry Gyroscope Company, Ltd., Brentford, Middlesex. The Sperry electric and automatic steering control is similar, in principle, to the company's two-unit "Gyro-pilot," using a bridge control unit coupled to an after power unit. However, by using duplicate cable runs from the wheelhouse to the after steering compartment and by incorporating an "auxiliary" switch, the electric and automatic system completely replaces the normal "Telemotor" and provides hand-electric, automatic and auxiliary steering control, with six choices of circuit for the purpose.

The Department of Scientific and Industrial Research

This exhibit as a whole illustrated the importance of scientific research to British industry and the manner of application of various instruments for the obtaining of information necessary for the improvement of industrial efficiency.

One of the items shown by Pametrada was an example of refractory turbine blading. The material can withstand temperatures of 1200 deg. Cent., and resist the thermal shock resulting from rapid cooling from 1200 deg. to 900 deg. Cent. Test specimens are heated to the required temperature and cooled by a blast of cold air, and are required to have a minimum tensile strength of about 4 tons per square inch over the range of temperatures. The blades, which are cast to final size, are produced by the slip cast method, the refractory mixture being poured into a plaster of paris mould. A special form of packing is used which holds the blades in such a manner that the metal casing is shielded from the hot gases.

The British Internal Combustion Engine Research Association demonstrated a noise test rig which enables a detailed study of each of the contributory noises with a view to the reduction of the overall engine noise, and for this purpose engine components are run separately in the rig. The method employed is to take an engine component and incorporate special pick-ups which form part of an indicating system and produce diagrams showing mechanical movement and the hydraulic pressure variations during the cycle of operations. This latter is obtained by using lapped fit plungers which act upon a condenser to cause a change in capacity. Corresponding diagrams are recorded, with the same time scale, which show the surface vibration and the resultant air pressure variations constituting noise. It is possible to link characteristics of the vibration and noise diagrams with certain features in the diagrams of mechanical movement or hydraulic pressure, and so trace various parts of the noise to their sources. Thus the total noise by a process of elimination is filtered down into components.

The instrumentation includes a double-beam oscillograph for indicating two cyclic changes simultaneously, various pick-ups, sound level meters, sound and vibration analysers, and a condenser pattern microphone with amplifier in the handle and a cathode follower circuit which changes a high impedance source to low impedance.

The Electricity Failure in North-West England

The British Electricity Authority has issued a statement on the recent breakdown of supplies to the Merseyside and North Wales Area Board, and the North-Western Area Board. According to this statement, the sequence of events was as follows.

At 4.57 p.m. on Monday, September 3rd, three heavily loaded grid connections supplying the Merseyside and North Wales Area and the western section of the North-Western Area, tripped in cascade, following an unexpectedly rapid rise in load. These connections were: the reactor at Percival Lane (connecting Percival Lane to Chester and Bromborough), the tee connection at Warrington (connecting Warrington to Wigan and St. Helens), and the Carlisle–Kendal line. The Dunston–Galashiels line, connecting the North-Eastern Area with the South-East Scotland Area, also tripped. The Blackburn–Quernmore and Crewe–Percival Lane lines were out of commission for maintenance at the time of the fault. At the time of the occurrence all the available generating plant in the affected zone was operating at maximum output. There was adequate spare plant on the remainder of the system.

The immediate effect of the fault that initiated the tripping of the lines was to isolate the Merseyside and North Wales Area and the western section of the North-Western Area from the remainder of the system, with a demand of nearly 40 per cent in excess of the available generating plant capacity. The frequency and voltage in this isolated section fell rapidly. Scotland also became isolated from the remainder of the system, but with sufficient generating plant to be self-supporting.

After the fault, load was shed extensively at the power stations in the Merseyside Area and the western section of the North-Western Area in an attempt to hold the frequency. This attempt was unsuccessful and the generating plant in the affected zone had to be taken off the busbars because of loss of auxiliary power or instability. As the plant failed, each station was cleared from the grid and local load restoration began as soon as generation could be resumed.

By 5.28 p.m., all supplies in the affected zone had been cleared from the grid, and at 5.39 p.m. the isolated section of the grid was made alive from the remainder of the system. The process of restoring load continued and was completed at 8.06 p.m.

Oil Refinery at Fawley

No. II—(*Continued from page 371, September 21st*)

THE coming on stream of the Fawley refinery represents the first step in a new trade pattern for the parent company's operation in the sterling area and is linked with the paramount importance of saving dollars. Conditioned by the same need other phases in the development of Fawley are going forward, such as the production of tractor fuel and lubricating oils, both of which projects are expected to be completed in 1954. Linked with the operation of the refinery is the question of keeping the dollar cost of tankers to a minimum and to this end not only has there been long-term chartering of non-dollar tankers but the Esso Petroleum Company, Ltd., has placed orders for a number of 26,500-ton deadweight tankers with several of the leading British shipbuilders. It is estimated that when the new trade pattern is in full operation the dollar cost of the company's operations in the sterling area will equal the average of the British and Dutch companies.

Last week we gave an overall review of the various units forming part of the refinery plant and in this issue we reproduce a flow chart, which serves to illustrate the various processes to which the crude oil is subjected from leaving the oil tanker until it is converted into the large number of end products designed to meet present-day requirements.

Distillation

Distillation of crude oil into its various fractions is the key to all petroleum refining and at Fawley there are two distillation units, which we illustrate, consisting of a single-stage atmospheric unit with a capacity of 48,000 barrels per day, and a combination vacuum and atmospheric unit, with a capacity of 63,000 barrels per day.

The crude oil brought by oil tanker is pumped from the marine terminal, illustrated overleaf, into ten floating roof storage tanks, which are mainly of welded steel construction, and which have a total capacity of about 1¼ million barrels, an amount which is sufficient to keep the refinery in operation for fourteen days. From the storage tanks the oil is run through a pipe still heater, which is of the two-flow system design, there being two convection and two radiant heating banks, capable of releasing 250 million B.Th.U.s per hour. After passing through the coils of piping lining the large brick furnace the temperature of the crude is about 800 deg. Fah., and it is in a partially vaporised form. Pipes lead it to the single-stage distillation unit, where, free to expand, all but the heaviest portions flush into vapour.

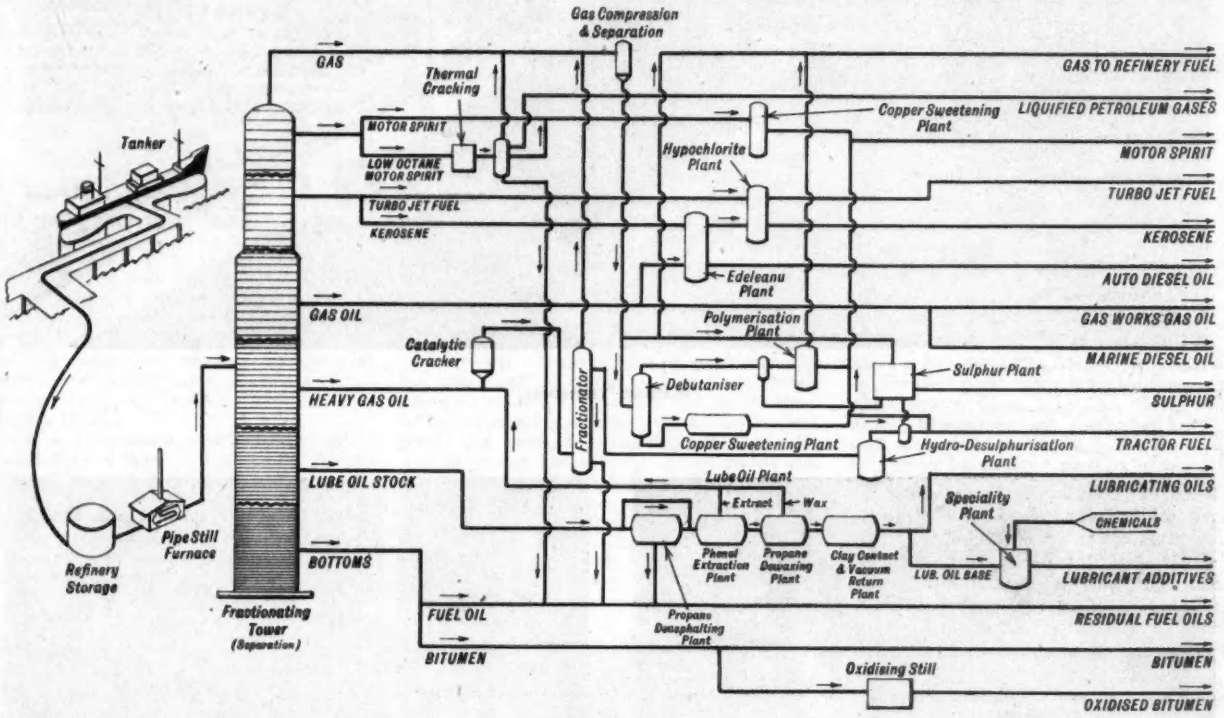
The fractionating tower is approximately 114ft in height by 21ft in diameter and is equipped with a number of perforated horizontal trays placed one above the other and fitted with bubble caps and overflow pipes. Those at the bottom, where the crude vapour is introduced, are the hottest and they become gradually cooler towards the top. Steam is introduced at the bottom of the tower to reduce distillation temperature and, to protect the inside surface of the tower from corrosive attack, monel metal and stainless steel cladding are used. The numerous components of crude oil have different boiling points and the vapours rise in the tower until their temperature falls to the point at which each becomes liquid. At this particular level they condense and collect in the trays as fractions with different characteristics and some liquid drops to the tray below through the overflow pipes. The rising vapours heat the liquid in the tray above by partially condensing as they pass through the bubble caps and the heat so generated releases the lighter vapours in that particular tray. The liquids also have a range of boiling temperatures and so they become segregated on the way down. Petrol collects in the top trays at about 100 deg. Fah., kerosene condenses lower down at approximately 300 deg. Fah., heating oil is drawn off at 500 deg. Fah., lubricating oil collects at 650 deg. Fah., and residual oils collect at the bottom. Each fraction is drawn off at its particular level ready for further processing. The unit is designed to produce the usual straight-run distillate cuts and to reduce the crude charge to a 25 per cent residual fraction.

Oil for the combination unit again passes through a pipe still, which is a double furnace unit. The section serving the atmospheric column has a heat release of 156 million B.Th.U.s per hour, while the second unit, which has one convection and one radiant bank, has a heat release of 85 million B.Th.U.s per hour. The atmospheric fractionating tower of the two-stage unit is smaller than that of the single-stage unit, being about 88ft high and in two sections, having diameters of 15ft 6in and 13ft, respectively. The vacuum tower is about 110ft in height and has a maximum diameter of 28ft. Both towers are clad internally with corrosion resistant materials. The two-stage unit, which is designed to distil crude oil to a 20 per cent bottom fraction, will separate an additional gas oil distillate fraction and the gas oil fraction will be used as stock for the catalytic cracking plant until the production of lubricating oil is commenced.

Both the single-stage and two-stage units are equipped with a complete heat exchange system, which can be seen in our engraving, and which is operated by a battery of pumps each rated to handle 18,750 gallons per minute. Situated between the units is the control house, containing the instruments shown in our illustration, by means of which it is possible for a team of seven men to control the refinery operations, valve operation being through a system of compressed air relays using the diaphragm principle.

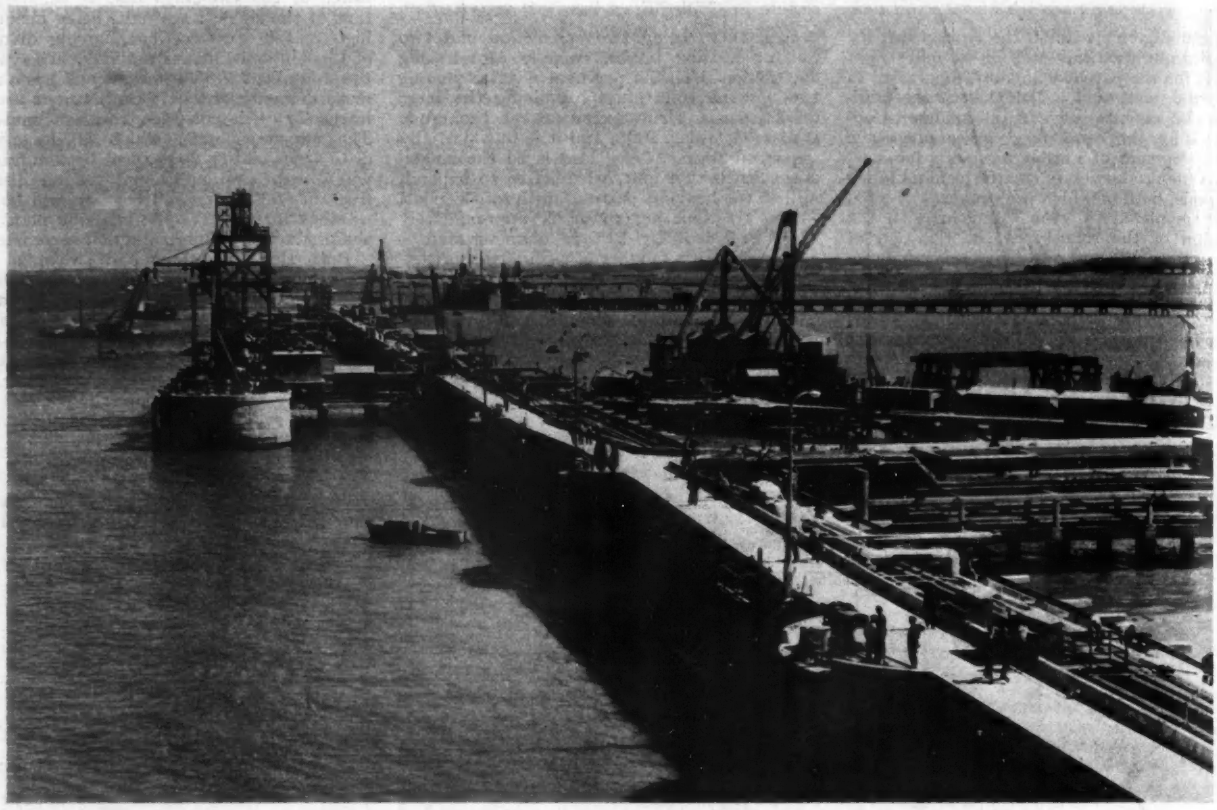
In order to obtain more petrol from crude oil than is obtained by straight distillation, certain distillate streams from the crude units are fed to a fluid catalytic cracking plant in which the essential process is the breaking down of large molecules to small molecules, using high temperatures. The unit, illustrated in our engraving, consists of a fractionating tower, some 130ft in height by 20ft in diameter, a reactor, in which the cracking reaction takes place, and which is 35ft in diameter by 70ft high, a regenerator 55ft in diameter by 70ft high and a storage hopper for the catalyst.

The catalyst, which is a clay, is so finely powdered that it flows like a fluid and in a preheated state it is injected into the reactor, along with the cracking stock. In a densely whirling cloud, at a temperature of about 1000 deg. Fah., the vapour comes into close contact with the catalyst, which becomes coated with carbon removed from the oil and drops to the bottom, while the cracked oil vapours are piped off and, after passing through cyclones to remove any entrained catalyst, are passed to the fractionating column. Here they are separated into various grades. The



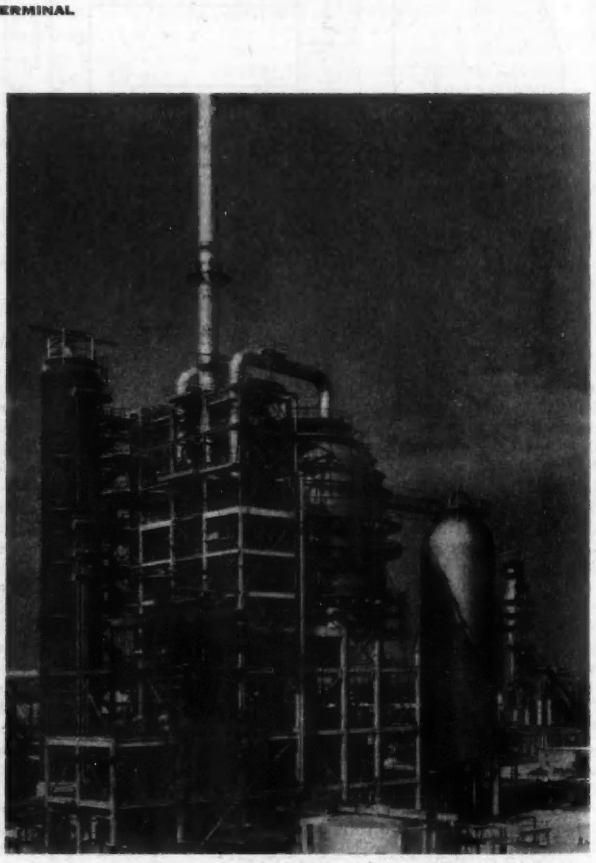
FLOW CHART

THE FAWLEY OIL REFINERY, HANTS.



MARINE TERMINAL

HEAT EXCHANGERS AND DISTILLATION TOWERS



FLUID CATALYTIC CRACKING PLANT

heavier groups may be reintroduced into the reactor for further cracking or use as blending stock for fuel oils. The wet gas and light gasoline pass to the debutaniser tower, which is about 10ft in diameter and 113ft in height, where butane and other light gases are removed from the motor spirit. The butane is stored as a liquid under a pressure of 60 lb per square inch in a sphere approximately 49ft in diameter.

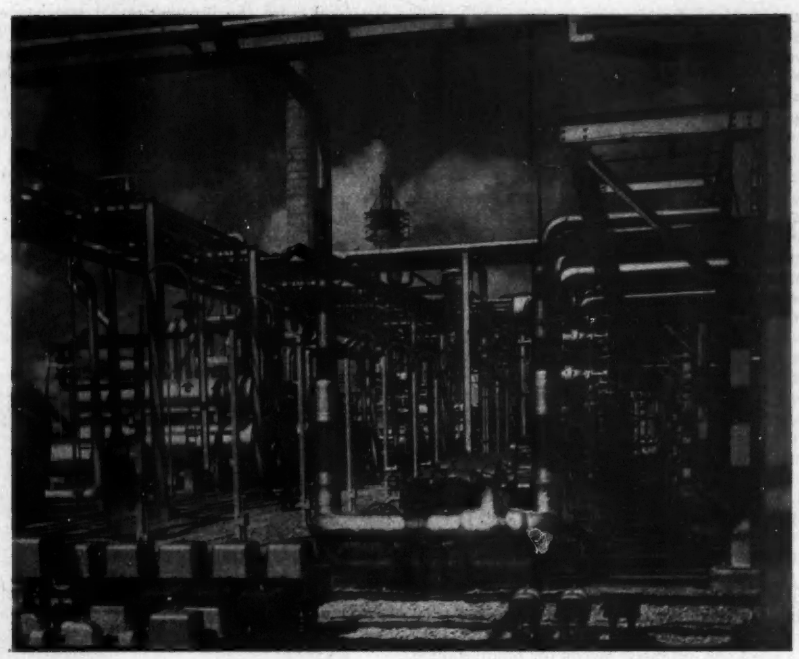
The spent catalyst is returned to the regenerator, where, at a temperature of 1200 deg. Fah., the carbon is burned off in a stream of air and the material then flows off to the reactor to complete the cycle. The flue gases from the regenerator, after passing through cyclones are used to raise steam in waste heat boilers. It is expected that 50 per cent of the output from the charge of 41,000 barrels per day will be high octane petrol for blending with raw petrol and the remainder for blending with diesel fuel, bunker fuel and heating oil.

Special Treatment Plant

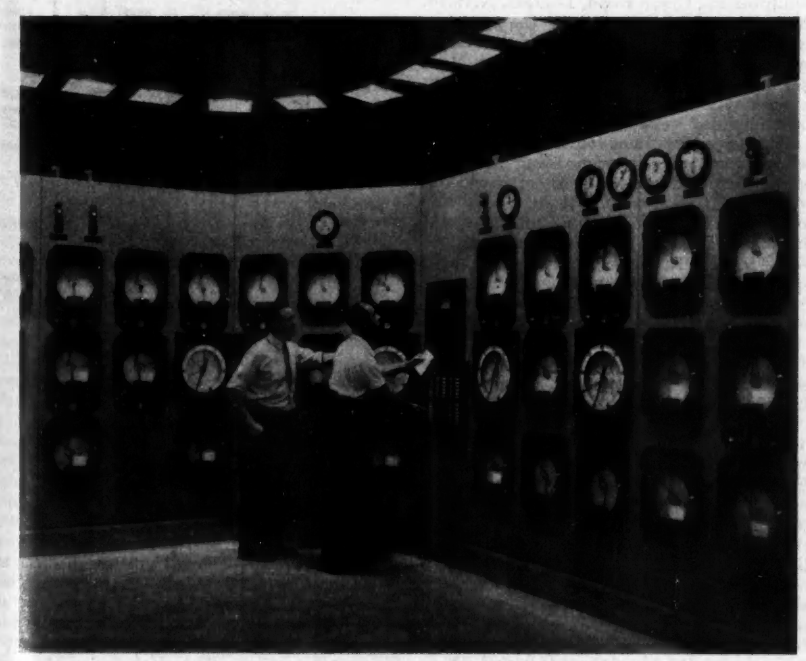
The crude oil to be charged at Fawley is being supplied from Middle East sources and has a high sulphur content so that treatment plant forms an important part in the processing work of the refinery. There is a copper chloride sweetening unit in which a chemical finishing process removes organic sulphur compounds and other unpleasant vapours from the straight-run gasoline before it is blended with the high-octane spirit from the catalytic cracker, which is treated separately. To improve the turbo-jet fuel and kerosene, they are treated in a hypochlorite plant, where unpleasant smelling sulphur compounds are removed. The hydro-desulphurisation plant removes the sulphur content of tractor fuel and this operation is carried out by desulphurising the tractor fuel, then mixing it with hydrogen and finally passing it over a bed of catalyst. Another treating equipment is the Edeleann plant, which is a sulphur dioxide extraction unit, in which liquid sulphur dioxide is mixed with raw kerosene to reduce the sulphur content and to remove other undesirable components and so produce an improved kerosene with superior burning qualities.

In the polymerisation unit butylene gas is converted into a high octane liquid in the presence of a solid phosphoric acid catalyst and the process, which is the reverse of cracking in that it builds small molecules up into large ones, plays an important part in the high octane gasoline production sequence. Contained in the gas from the fractionating tower are a number of materials, which can be condensed at ordinary temperatures and in the gas compression and separation unit all recoverable material is removed from the gas, which is then piped to the refinery fuel mains. Low octane motor spirit from the fractionating tower is passed through the thermal cracking unit, where it is converted into high-octane spirit plus a certain quantity of gas by the use of heat and pressure, but without a catalyst.

As already mentioned, gas oil stock from the two-stage unit is being used as feed for the catalytic cracking plant but will be diverted to the lubricating oil plant when that is complete. To produce lubricating oils the stock will be treated successively in four plants and these, when completed, will consist of a propane de-asphalting plant, in which liquid propane extracts asphaltic substances from raw high viscosity lubricating oil distillates and provides improved quality stock for subsequent processing. At the next stage "aromatics," which have poor lubricating properties, are removed in a phenol extraction plant, which is a selective extraction process and represents a significant development in refining technology. The third step is treatment in the propane de-waxing unit, where liquid propane mixed with refined raffinate from the phenol extraction plant crystallises the wax, which is filtered from the oil and returned to the catalytic cracker. The removal of the wax produces a lubricating oil, which will remain fluid at low temperatures. Finally there is the clay contact rerun unit, in which the de-waxed lubricating oil distillates are mixed with a special absorbent clay and then re-run, under vacuum, to produce a finished and stable lubricating oil having a green fluorescent appearance. The lubricating oil base will be passed to a speciality plant, where it will be mixed with certain chemicals to produce anti-corrosive additives for lubricating oils.



Heat Exchangers and Pumps



Control Room

Among the residual fractions is bitumen and at Fawley part of this stock will be passed through an oxidising still, in which air is blown through the hot residue to produce oxidised bitumen, a rubbery substance, which has special uses, such as in the manufacture of roofing felt. Another major plant which is under construction is that for the production of sulphur. The sulphur recovery plant, when completed, is expected to produce 12,000 tons per year. Two gas streams will provide the source of hydrogen sulphide for the sulphur recovery operation. It is understood that gases from the polymerisation unit and the hydro-desulphurisation plant will be cleaned in hydrogen sulphide removal units and the mixture of the resulting acid gases will be converted in the recovery plant into 99·5 per cent chemically pure rock sulphur.

When in full operation the refinery will employ a permanent staff of 2500 and a number will be able to live in the immediate vicinity in houses at present under construction within the refinery area. The social life of the community has not been overlooked, for a social club has been built on the Esso sports ground. This building, beside offering a wide range of social facilities, includes an up-to-date cinema with a seating capacity for 500.

Auxiliary Services

Steam for the working of the various services is supplied by four Babcock and Wilcox boilers, each generating 95,000 lb of steam per hour at 150 lb per square inch pressure and 465 deg. Fah. In the lay-out of the boiler-house provision has been made to supply the

steam required for future developments and three Foster-Wheeler two-drum, water-tube generator units are to be installed. Each of these will have a capacity of 110,000 lb of steam per hour at 150 lb per square inch and a temperature of 465 deg. Fah., using feed water at 240 deg. Fah.

Water supplies for the boilers and process work is supplied partly by the Southampton water works and partly from wells, which have been sunk within the refinery area. Cooling water is drawn at a rate of 75,000 gallons per minute from Southampton Water and pumped through a 60in diameter and two 48in diameter mains to storage tanks from where it is delivered under pressure to the heat exchangers, &c. After use the cooling water is returned to a series of settling tanks, where any oil which may have leaked into it is removed before it is returned to Southampton Water in an uncontaminated condition.

In addition to the storage tanks for crude oil and cooling water there are tanks for storing the refinery products, with a total capacity of 4,000,000 barrels, representing about thirty days' production. Most of the 220 pumps are electrically driven and the necessary power is supplied from the grid, but to guard against the great danger due to any untoward failure, a number of steam pumps have been fitted to enable the refinery to close down gradually without any major disaster occurring.

To meet the extensive needs for maintenance of a refinery of this size, a large steel-framed building was erected. It is 800ft long by 180ft wide and serves as a combined workshop and warehouse, and is fully equipped with modern machines in well planned shops and has every facility for the repair of any part of refinery plant when the need arises.

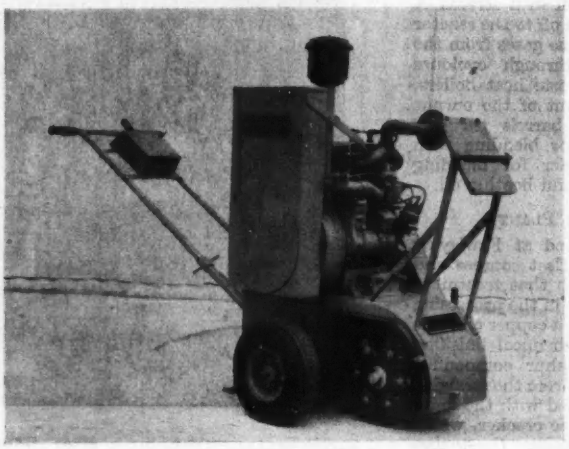
Flue gases from the pipe stills and the boiler plant are discharged into the air up concrete chimneys which rise to a height of 250ft and so ensure the safe dispersal of the gases. Waste gases from the various refinery units are burned in the flare stack.

The design of the project was in the hands of the Standard Oil Development Company and the main contractors for the refinery units were the Foster-Wheeler Corporation, the direct supervision of the work being under Foster-Wheeler, Ltd. A large number of contractors have been engaged on the project, including, it is understood, for the storage tanks, William Neill and Son (St. Helens), Ltd., and Whessoe, Ltd.; concrete piping, Sharp Jones and Co., Ltd., and Stanton Iron Works Company, Ltd.; piping, Claycross Company, Ltd.; Staveley Coal and Iron Company, Ltd., and Stewarts and Lloyds, Ltd.; marine terminal, Christiani and Nielsen, Ltd.; pumps, Babcock and Wilcox, Ltd., Gwynnes Pumps, Ltd., and Sigmund Pumps, Ltd.; waterwells, International Water Corporation, Ltd., and C. Isler and Co.; electrical substations, switchboards and motors, Metropolitan-Vickers Electrical Company, Ltd.; interior lighting, General Electric Company, Ltd.; buildings, John Laing and Son, Ltd.

Cleaning and Sealing Joints in Concrete Roads

One of the more tedious tasks in road maintenance is that of cleaning and resealing the joints in concrete roads. Last week, the Road Research Laboratory organised demonstrations of four machines, which were brought together to illustrate modern methods of cleaning and sealing such joints, and to show how this work lends itself readily to mechanisation, thus saving time and labour and producing a better job. The Road Research Laboratory hopes that as a result of these demonstrations the manufacture of such machines in this country will be encouraged. The demonstrations were arranged by courtesy of the Ministry of Transport and the County Surveyor of Surrey, and took place on one of the dual carriageways of the Kingston by-pass.

The first of the four machines, which is illustrated herewith, is intended for cleaning the joints and reshaping the arrises. As may be observed from the illustration, it consists of a rotary cutter driven by a petrol engine. The machine at the demonstration was manufactured in the U.S. by the G. H. Tennant Company, and is driven by a 13 h.p. engine. The cutter rotates at 2400 r.p.m.; it consists of two circular plates with six cutting wheels mounted between them around the periphery. The six cutting wheels rotate



Machine for Cleaning Joints and Reshaping Arrises

freely, and have a "flail" action. The first time a cutting wheels hits the surface to be cleaned it is caused to rotate and starts to cut at the second impact. The depth of cut is controlled by a pilot wheel, which is mounted on the far side of the machine and cannot be seen in the illustration. The spacing of the cutting wheels can be varied to cut grooves from ⅜in to 2¾in wide. The operator guides the machine with the aid of a mirror, mounted at 45 deg. above the rotary cutter. The machine operates at a slow walking pace and the cutting wheels should be changed after about 150 or 200 yards' work.

The second machine is a rotary wire brush, which is again petrol engine driven, and is used for cleaning the shaped joints. It can be operated at a normal walking pace. As in the case of the first machine, the depth of working is controlled by a pilot wheel. The machine at the demonstration was manufactured for Expandite Ltd., Chase Road, London, N.W.10.

The machine which is used for the next two stages, blows dust from the joint with a compressed air jet, and applies a bituminous primer in one operation. The machine operates at a normal walking pace. It is, in fact, a slightly modified version of the machine used for marking white lines on roads, the one shown at the demonstration being manufactured by Tarpen Engineering Company, Ltd., Ixworth House, London, S.W.3.

Pouring the sealing compound into the joint is an operation which at present must still be done by hand. However, the preparation of the sealing compound is carried out in a mobile thermostatically controlled heater. This machine consists of a tank, which is oil jacketed and heated by "Calor" gas. The temperature may be controlled by thermo regulators over a range of temperature from about 40 deg. Cent. to 320 deg. Cent. There are two pilot burners and two main ones; the pilot burners are each connected to a relay so that should one of them go out the gas supply is closed. The capacity of the machine is 120 gallons, and it holds 115 gallons of oil. There are several tubes to circulate the oil through the tank to give better heating. The tank itself is divided into a loading and a draw-off compartment by a partition which prevents lumpy material passing to the draw-off side. There is a manually operated paddle near the draw-off cock, to prevent it being blocked. The machine was built by Aeroil Products Company, Inc., New Jersey, and was developed for use with rubberised bitumen sealing compounds.

A Pressure Relay

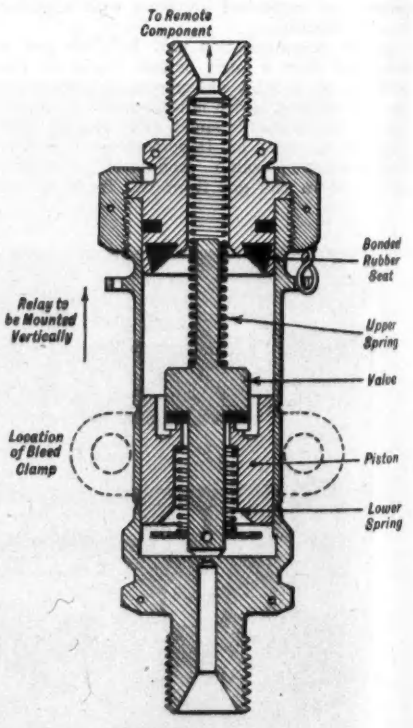
A contribution to safety measures in hydraulic systems is a new pressure relay produced by the Dunlop Rubber Company, Ltd.

This relay is a compact safety device suitable for insertion in subsidiary pipe runs serving remote single-line components—pressure gauges, switches, &c. Its purpose is to prevent automatically the total loss of fluid from a main system if failure of a subsidiary line or component should result in a leak. The arrangement of the unit can be seen in the diagram we reproduce below. It has a stainless steel cylinder with an integral pipe connection at one end and at the opposite and open end is a counterbored brass head, sealed by a rubber ring and retained by a sleeve nut.

A pipe connection is machined on the head and the inner mouth of the counterbore is lipped by an annular rubber seat bonded to the metal of the head. Within the cylinder is an aluminium-bronze piston, with a central raised valve seat carrying a double-stemmed rubber-seated valve.

The valve is spring loaded upon its seat in the piston which encircles its lower stem, and a second spring, loaded beneath the head and located upon the upper valve stem tends to hold the piston at the bottom of the cylinder.

If the relay and subsidiary line are correctly primed with fluid, the piston and valve together function as a separator when the main system



Pressure Relay

pressure is applied. In so doing, they move up the cylinder, expel a small volume of fluid, and give an equivalent pressure in the subsidiary line.

If the pressure in the outlet line above the piston and valve is released, they are moved to the top of the cylinder by the fluid pressure of the main system. The shoulder of the valve then seats on the rubber insert in the head and prevents the escape of fluid.

Modern Developments in Reinforced Concrete Design*

By HJALMAR GRANHOLM†

WHEN a reinforced concrete structure is planned, it is found that the cheapest structure is obtained if the dimensions are determined in such a way that the cost of the concrete is approximately the same as the cost of reinforcing. This fact indicates that it is equally important to develop both components, and that the most satisfactory solution, from the economic viewpoint, will not be achieved until the cost of both the concrete and the reinforcement has been pushed down to the lowest limit technically possible.

The minimum requirement for the achievement of this object is that the strength of both materials shall be exploited to the greatest extent technically possible. In what follows I shall try to sketch out the way in which the developments of the past few years have now made it possible to utilise to the full, on the one hand, high-quality reinforcing steel, and on the other hand, the strength of concrete, which up to the present has been considerably underestimated.

Immediately before the second world war, high-quality reinforcing steel came into general use. Reinforcing steel St 52, with a yield limit of 3200kg to 3400kg per square centimetre, then came, to a great extent, to replace the hitherto normal reinforcing steel St 37, with a yield limit of 2200kg per square centimetre. The permissible stress, which for the normal reinforcing steel had usually been put at 1100kg to 1200kg per square centimetre, was put for the high-quality steel at 1700kg per square centimetre. At the time, this was considered a gigantic step forward, and implied a considerable increase in the competitive power of reinforced concrete. In those days, however, it was not always so easy to persuade the authorities that there was no danger in permitting such a heavy stress. Since then, developments have gone a good deal further in this field, and nowadays one reckons on an even heavier permissible stress on the reinforcing steel than in the years just before the last world war. It may be mentioned that the Swedish Government regulations about the use of concrete for the year 1949 lay down permissible stresses for reinforcing steel St 52 as indicated in the table below.

The thing that limits the permissible stress on the reinforcement, however, is not so much the ability of the metallurgists to produce a steel with high yield limit and high ultimate strength, but much more the risk of cracks developing in the concrete. This problem is intimately connected with that of the bond between concrete and reinforcement. The problem of cracking and of this bond is, at present, one of the most important in concrete technology. Great efforts have, therefore, been made to achieve a closer bond between concrete and reinforcement, in order to reduce the risk of the occurrence of large and concentrated cracks. To this end there are two possible methods. One is to work with light reinforcing rods, the other is to finish the reinforcing rod with a corrugated surface. The latter method has long been utilised, especially in America, where many different types of corrugated reinforcing rod are on the market. During the war, intensive research was carried out in Sweden on this type of reinforcing rod, and has resulted in the adoption of a standardised Swedish corrugated rod, in which the spacing between the corrugations is not more than 0·8 times the diameter of the rod. On a length of, at most, four times the diameter of the rod, the sum of the areas of the corrugations projected on a plane perpendicular to the longitudinal axis of the rod is at least equal to the area of the rod.

In general, a material is used for corrugated rods with a yield limit of at least 40kg per square millimetre. The Swedish concrete regulations have set the permissible stress as high as 2200kg per square centimetre for reinforcing rods with a diameter equivalent to 16mm and under. It is further stipulated that the compressive strength of the concrete is at least 250kg per square centimetre and that the structure is subjected to static loading. For dynamically loaded structures and for heavier reinforcing rods and for concrete with lower compressive strength, the permissible stress of the reinforcing rod is reduced in approximately the same way as is shown in the table for St 52.

During the last ten years, a large number of bridges, industrial buildings and blocks of flats have been constructed in Sweden, using corrugated rod reinforcement. Originally, the highest permissible stress was fixed at 2000kg per square centimetre. The experience of these structures has proved so favourable, however, that the authorities have considered it possible to raise the permissible stress to 2200 for rods with a diameter of 16mm or less.

Thanks to the transverse and rather steep corrugations, such a good bond is achieved between the concrete and the steel that it has been possible to put the permissible bond stress very high, exactly twice as high as with smooth rods. According to the compressive strength of the concrete, the permissible bond stress varies between the limits of 13–19kg per square centimetre, when the cube crushing strength of the concrete varies between 200kg and 400kg per square centimetre.

This high permissible bond stress means that, in practice, no end hooks are necessary on the corrugated rod. Apart from anything else, the fact that end hooks have become superfluous means a great simplification of the work on the building site. It seems possible, however, that the present upper limit for the permissible stress on the reinforcement could well be raised even further, without any overstepping of the danger limit and without cracking becoming troublesome.

In 1944, I carried out experiments, first on a small scale in the laboratory, and afterwards on a full scale, with an extra high-quality deformed reinforcing steel. This steel had a yield limit of about 6000kg per square centimetre and an ultimate strength varying between 8230kg and 8650kg per square centimetre. These remarkable qualities were to be attributed to the rather high percentages of carbon, silicon and manganese, namely,

C = 0·40 to 0·60 per cent.
Si = 1·50 to 1·80 per cent.
Mn = 0·60 to 0·70 per cent.

From the results of the laboratory research, I considered that it should be possible to permit a stress on the reinforcement as high as 3300kg per square centimetre without cracking becoming abnormally severe. A condition for this, however, was that the diameter of the reinforcing rod should be limited to 14mm.

The full-scale experiment which was then carried out employed ten roof beams with a span of 22·8m for an industrial property in Stockholm. The cross section of the beams and the reinforcing are shown in Fig. 1. The tensile stress, calculated according to stage 1, amounts to no less than 98kg per square centimetre, and the stress on the steel, as said earlier, to 3300kg per square centimetre. The compressive stress on the concrete (reckoned according to stage 2 with $n = 15$) amounts to 125kg per square centimetre. After twenty-eight days, the compressive strength of the concrete amounted to 400kg per square centimetre. The structure thus differs from the conventional in many respects. It may, therefore, be of value to give an account of the experience which has been gained up to now with this rather extreme experimental structure.

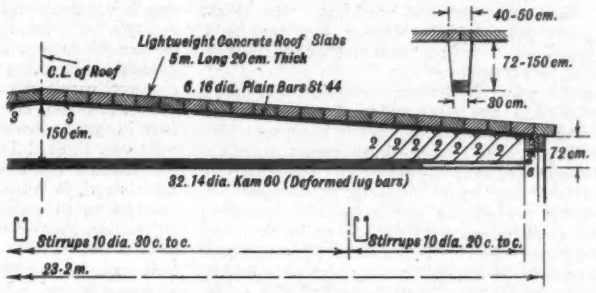


FIG. 1—*Experimental Roof Beam*

To reduce cracking as much as possible, the girders were made trapezium-shaped and tapering downwards so that the reinforcement was heavily concentrated in the zone under tensile stress. After six years, the experience with this building is entirely favourable. Thanks to the tightly packed light reinforcing rods and their bond with the concrete, cracking is negligible. The greatest breadth of crack measured is only 0·10mm. Most of the cracks are even finer, about 0·06mm broad. The cracks lie rather close to one another, with a spacing of 15cm to 20cm.

For the present, however, the practical application has been limited to this one structure, while laboratory research has continued with the object of finding a corrugated rod with even better bond qualities than that now in use. The method that can then be followed is to increase the total area of the ridges, on the one hand by packing them more densely, and on the other by increasing the surface area of each ridge. Particularly promising results have been obtained with a corrugated rod in which the area of the ridges is about 2·5 times as great as on those hitherto used in Sweden.

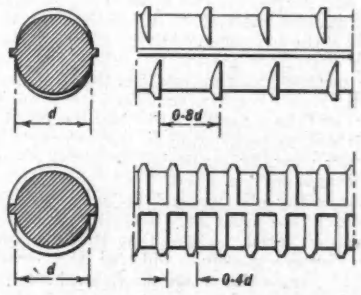


FIG. 2—*Corrugated Reinforcing Rods*

Fig. 2 shows both types of corrugated rod, the older standardised type with elliptical ridges, and the new experimental type with circular ones. The projected area of the ridges per unit length for the two types is 0·20 d and 0·47 d respectively.

It is to be expected that, with a reinforcing rod of this or a similar type, it will be possible to make structures freer from the danger of cracking than hitherto. It seems to be within the bounds of possibility to achieve a per-

Permissible Stress for Reinforcing with St 52
(Yield limit 32–34kg/mm², ultimate strength 52–65kg/mm²)

Compressive strength of the concrete	Statically loaded structures		Dynamically loaded structures	
	$d \leq 16$mm	$d > 16$mm	$d \leq 16$mm	$d > 16$mm
250kg/cm²	2000kg/cm²	1700kg/cm²	1600kg/cm²	1500kg/cm²
200kg/cm²	1800kg/cm²	1400kg/cm²	1400kg/cm²	1300kg/cm²

* Abstract from a paper presented to the Building Research Congress.

† Professor of Building Technics, Chalmers University of Technology, Gothenburg, Sweden.

missible stress on the reinforcement, for ordinary concrete without prestress, of over 3000kg per square centimetre, or even in the region of 4000kg per square centimetre, and it is probable that the next decade will bring important progress in this field.

In general, efforts to achieve a high yield limit and ultimate strength in the reinforcing material have up to now been made by using additional ingredients, e.g., silicon and manganese. However, other methods have also been practised and have won a not inconsiderable popularity. I am referring to the fact that a considerable increase in the yield limit and also the ultimate strength of the rod can be obtained by cold working. Here, use has been made of twisting alone ("isteg" and "torstahl"), or stretching alone, or stretching followed by twisting (tentor steel). By these methods the yield limit of the reinforcing iron can be increased by 50–80 per cent, the exact increase depending on the original material and the degree of cold working. The cold-worked rod is employed in the same way as a naturally hard one, and is manufactured either smooth or with ridges.

In this way, results can be achieved of great interest and practical value. For example, one can begin with a high-grade basic material and subject it to cold working, thus raising its yield limit and ultimate strength. The Austrian "torstahl 70," with a tensile strength of 10,000kg per square centimetre, is manufactured from a material with a yield limit of 5500kg per square centimetre. The Austrian concrete regulations allow very high permissible stresses on reinforcing materials of this type. Thus, with "torstahl 60," with a yield limit of 6000kg per square centimetre, no less than 3500kg per square centimetre is permitted for statically loaded structures, provided that the compressive strength of the concrete‡ is at least 225kg per square centimetre.

The competition which has recently sprung up between naturally hard and cold-worked reinforcing steel is a great benefit to concrete technology. In some countries cold-worked rods are already more popular than naturally hard ones, which shows the competitive power of the new manufacturing method. In other countries, on the other hand, naturally hard, high-grade steel is still simpler and cheaper to produce, and so, for the present, still dominates the market.

Methods of Calculation

The foundation for the calculation of reinforced concrete structures has been, and still is, the theory of elasticity, which has been built up and shaped on the basis of Hooke's Law. The present method of calculation, which, in view of the completeness that has been attained, may with good reason be called the classical method, postulates that the constituent materials of a concrete structure, the reinforcing steel and the concrete, both obey Hooke's Law. It is well known, however, that Hooke's Law is only partially applicable as far as concrete structures are concerned.

Especially obvious are the departures from Hooke's Law when large loads are in question. It cannot, then, be said that Hooke's Law is even approximately valid for the concrete portion, since the actual stress/strain diagram for the concrete has not the remotest resemblance to the straight line of the classical theory. The same is, to a great extent, true also of the reinforcing steel, whose stress/strain diagram admittedly conforms to the conditions for an ideal elastic material up to the yield limit, but thereafter, and especially in the characteristic yield region, conforms more nearly to the requirements for an ideal plastic material. It is, therefore, quite natural that the classical theory has been unable to give a correct picture of conditions in a concrete structure, especially when it proves to be near the breaking stage. Nor is it possible to modify or improve the classical theory in such a way that it can be used to study the breaking stage in a concrete beam. Certainly attempts have been made, by introducing a certain suitable value for the modular ratio n, to bring about a better agreement between theory and reality, but experience has shown that the goal can hardly be achieved by this method.

Rather than thus to attempt by small adjustments to improve the classical method, it is more correct to abandon the elasticity theory completely, and build up an entirely new theory which takes account of the actual properties of the material used. Theory must thus regulate itself entirely according to practice, instead of being forced, as hitherto, to follow certain predetermined lines. The remarkable thing is that, perhaps contrary to expectation, a new theory is obtained that is quite as simple as the classical theory, and at times even simpler.

It is a well-known fact that, by adjusting the permissible stress in a suitable way in relation to the value of n, results can, in fact, be obtained by means of the classical theory which give an approximate understanding of the danger of breaking in a reinforced concrete structure. In such circumstances, the way in which the value of n is chosen is of minor importance. Provided only that a suitable permissible stress is chosen for the concrete (which has nothing to do with the real stress), a correct result can always be reached.

It must be clearly understood, however, that in great measure this is feasible only in a relatively limited field, and that, as soon as the properties of the concrete or the reinforcing steel are altered, it is necessary to check up on the calculating procedure by further experiments. Otherwise, there is considerable risk of arriving at an incorrect result.

In face of the developments now imminent in concrete technology, in the direction of the use of ever higher quality reinforcing steel with very high permissible stress, these difficulties may soon become too great. There is, therefore, every reason to look for a way out of the difficulties, and to adopt a method of calculation that is liberated from the viewpoint of the classical theory.

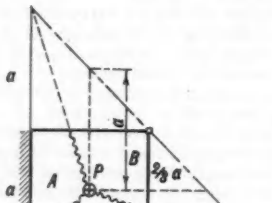


FIG. 3—*Fracture of Square Slab*

This new method of calculation and of dimensioning received its first development from Saliger, and was later developed and studied by a number of investigators. It is based on very comprehensive and completely convincing experimental material. The correctness of the "n-less method" of calculation, as it is sometimes called, can be vouched for by a large number of trials which, in the course of years, have been carried out in various places and by various workers.

The advantage of the new method of calculation is that it takes full account of the strength of the concrete, whereas the classical theory easily falls into the error of underestimating it. Since the new theory thus corresponds to reality more nearly than the classical, slenderer and cheaper concrete structures can be achieved. Dimensioning is carried out very largely as with the classical theory, according to the well-known formula :

$$h = r\sqrt{\frac{M}{b}},$$

where the coefficient r does not depend, as it does in the classical theory, on the permissible stress and the value of n, but instead is determined by the equation,

$$r^2 = \frac{1}{\alpha\sigma_b^1}.$$

In these formulæ,

M = the bending moment, multiplied by the safety factor.

σ_b^1 = the effective compressive strength of the concrete, which can be reckoned as a certain fraction of the cube or cylinder strength. In general, σ_b^1 can be made equal to 0·70 to 0·80 σ_{cube} (shape factor).

α = a coefficient, the size of which depends on the ratio between the maximum strain of the concrete before breaking, and the elongation of the reinforcing steel when the yield point is reached. Normally, it lies between the limits 0·37 and 0·45.

When the safety factor is being determined, it is, above all, necessary to take into account the spread of strength, which for concrete can be quite considerable. Spread depends on factors which are difficult to gauge, such as the construction of the concrete mixer and the care with which the work is carried out.

Furthermore, the amount of cement seems to have an influence, and in such a way that a larger quantity of cement gives increased spread. Certain preliminary studies of practical value have already been carried out in this field, but a good deal of research remains to be done before we can obtain a surer understanding of spread of strength, and thereby determine the safety factor. The problem is fundamentally the same for all building materials, but, as compared with such materials as timber and brickwork, concrete occupies a unique position, in that the spread of strength can often be very pronounced.

Hitherto, it has been the practice to set out from the approximate hypothesis that the spread follows the normal Gaussian function, but it must be clearly understood that this is only an approximation, which in certain cases can lead to incorrect results. The safety factor can also be determined in such a way that different multipliers are used for different kinds of loading. Thus, for the permanent load, which can be calculated tolerably exactly, a lower multiplier can be chosen than for the live load, which can be more difficult to estimate in advance. By this means, a better chance is obtained of taking into account the actual situation than is possible to the classical theory with its fixed stress.

The coefficient α in the formula

$$r^2 = \frac{1}{\alpha\sigma_b^1}$$

is particularly interesting. Its magnitude can be calculated as soon as we know the plastic deformation capacity of the concrete and the yield limit of the reinforcing steel. If it is assumed that the maximum plastic deformation or ultimate strain of the concrete amounts to 4 per mille (which is a reasonable value), the following figures are obtained :—

α = 0·45 for reinforcing steel with a yield limit of 2200kg per square centimetre.

α = 0·41 for reinforcing steel with a yield limit of 4000kg per square centimetre.

α = 0·37 for reinforcing steel with a yield limit of 6000kg per square centimetre.

In general, α can be calculated from the equation,

$$\alpha = 2\beta\frac{m_o}{(m_o+1)^2}[1+(1-\beta)m_o],$$

where

m_o = the ratio between the maximum compressive strain of the concrete before breaking and the elongation of the steel at maximum tension (generally at the yield point).

β = a coefficient of magnitude 0·40 to 0·45. It depends on the shape of the stress/strain diagram of the concrete. For triangular distribution of stress $\beta = \frac{1}{B}$ (centre of compression factor).

For concrete with prestressed reinforcement, the value of α becomes dependent partly on the ultimate strength of the reinforcing steel and partly on the degree of prestress. The higher the prestress selected, the higher the value of the coefficient α. Structures in prestressed concrete can thus be dimensioned without difficulty, and calculated with due regard to the plastic deformation capacity of the concrete.

To make this clear, let us calculate the breaking moment for a prestressed concrete beam. We will assume the following :—

Strain of the concrete at breaking point = 4 per mille per cent.

Ultimate strength of the reinforcing steel

‡ See the original paper for the bibliography.

=24,000kg per square centimetre. Ultimate elongation=15 per mille per cent.

Prestress of steel=11,000kg per square centimetre, elongation=6 per mille per cent.

It follows that

$$m_o=\frac{4}{15-6}=0\cdot445.$$

With

$$\beta=0\cdot425,$$

we obtain

$$\alpha=0\cdot266.$$

This method of calculation, based on the plastic deformation properties of the concrete in the breaking stage, pays as little attention as the classical theory to the magnitude of the deflections.

It is, therefore, always necessary to convince oneself that the structure is sufficiently rigid. It is necessary to pay particular heed to the fact that shrinkage and creep on the part of the concrete combine to increase the deflections substantially. This often means that the effective depth of the beam or slab as calculated above must be increased considerably. More than once, great inconvenience has been caused owing to insufficient flexural rigidity and consequent great deflection because of creep. Nor does this method of calculation necessarily lead to the most economical structure; for the economic beam depth is not determined by the strength and deformation properties of the concrete and the reinforcement, but by the relative prices of concrete and steel, which depend on the state of the market at the moment in question, and can vary enormously from time to time.

Levelling and Redistribution of Moments

Nowadays, statically indeterminate structures are generally calculated with the help of the theory of elasticity. It is thus assumed that Hooke's law is fully valid and that the flexural rigidity EI is a constant and entirely independent of the loading. Here, however, a rather serious error is committed, for it appears that the flexural rigidity EI is far from being a constant, and that, even in the region of the permitted working stresses, it varies very considerably according to the loading, the flexural rigidity sinking as the loading increases. With very large stresses, especially in the neighbourhood of the breaking point, the flexural rigidity is reduced even further. The method of calculation in normal use pays no regard to this fact. To get full agreement with practice it is necessary to build up a new theory based on the actual properties of reinforced concrete.

Where steel structures are concerned, this problem has been fruitfully studied for the past twenty years or more, and in this field results have been reached which have achieved general application in practice in connection with the dimensioning of statically indeterminate steel structures. In these structures, one can often reckon on a levelling or an equalising of moments, in such a way that, through plastic deformation of the material, a heavily loaded section is eased and the moment taken by other parts of the structure, originally less strained. For steel structures, this levelling out of the load has been studied in detail, and it has thereby been possible to lay down the conditions under which levelling out can take place without the structure being unduly deformed. Despite the fact that a good deal of research work has already been carried out, there remains a considerable amount to be done in this field, as far as reinforced concrete is concerned, before the problem is satisfactorily elucidated. However, the experimental material that is available shows quite clearly that a calculation according to the theory of elasticity often gives results that do not at all correspond with reality.

In practice, therefore, it has to a considerable extent been customary, especially when it concerns statically loaded structures and ones where possible cracking is not of great importance, to depart from the theory of elasticity and, instead, carry out dimensioning by the breaking load method. The disadvantage of the breaking load method is that it involves a great local reduction in flexural rigidity, and hence cracking, possibly in connection with plastic yield of the reinforcement. The chief problem, therefore, is how cracking can be kept down to a safe level. This problem is of such practical and economic importance that intensive study should be devoted to it. It is primarily applicable to such structures as continuous and built-in beams, frames and arches.

With this type of structure must also be classified plates and slabs, which are to be considered as multiple statically indeterminate structures, where there are considerable opportunities for the equalisation and levelling of moments. In most countries, reinforced concrete slabs are calculated on the basis of what most designers believe to be the theory of elasticity. In actual fact, the moments are determined by the elasticity theory, while dimensioning takes place in accordance with the theory of plasticity. This inconsistency appears particularly clearly when dimensioning is carried out for the reinforcement of an oblong rectangular two-way slab, where, in fact, by the present methods of calculation, the reinforcement is distributed in the long and short directions, not in conformity with the requirements of the theory of elasticity, but rather of the theory of plasticity. Thus, the reinforcement in the long direction is considered to be subject to as much stress as the reinforcement in the short direction, which, according to the elasticity theory, is impossible. Other details concerning reinforcing are based on similar inconsistencies. In the long direction, where the curvature and the moment are less, and where, moreover, the inner lever arm is often shorter, the permissible stress should be made lower than in the short direction. Designers never do this, however, and shut their eyes to the inconsistency. The current method of dimensioning for two-way reinforced concrete slabs is thus a blend of the elasticity and plasticity theories, without the boundaries being clearly drawn. Even if the elasticity theory still maintains its great importance, yet it is of great consequence that it should be supplemented by a theory in which the special properties of reinforced concrete find better expression. Moreover, a theory of this kind, well worked out in all details, is available. It also agrees well with empirical experience. This is the line of fracture theory.

In Denmark, and, to a certain extent also, in the other Scandinavian countries, it is used for calculating two-way reinforced slabs.

The method is based on the assumption that, in the breaking stage, the reinforced slab breaks along certain lines, the so-called lines of fracture, and that the change of angle along these lines is so great in comparison with the deformations in the other parts of the slab, that these latter can be neglected. It is further assumed that the moment at the line of fracture amounts to a value corresponding to the full utilisation of the reinforcement up to the yield point of the steel along the whole line.

The line of fracture theory makes it possible to study satisfactorily slabs of irregular shape and with arbitrary boundary conditions or with arbitrary loading, without the calculations getting particularly complicated. Even in the case, relatively common in practice, where a slab is supported along three edges and free on the fourth, calculation by the elasticity theory, as is known, can already be rather complicated. The line of fracture theory, on the other hand, admits of a simple solution of the problem.

The method can be illustrated by an example. A square slab, simply supported on two adjacent sides and by one column in the opposite corner, is loaded with a single force P in the centre. The figure of fracture will be as in Fig. 3. When the force P is lowered $\delta=1$, the parts A of the slab will obtain the rotations

$$1:\frac{a}{2}=2:a.$$

The rotations of part B will get the components $1:a$. The corresponding moment has the components $\frac{2}{3}ma$, where m denotes the moment per unit length of the slab.

Hence is obtained the equation of work:

$$P=ma\cdot\frac{2}{a}+2\cdot\frac{2}{3}ma\cdot\frac{1}{a}=\frac{16}{3}m$$

$$m=\frac{3}{16}P.$$

This short demonstration of the line of fracture theory shows how simple it is in application. It therefore deserves to be generally known, and gives us wider opportunities for building in reinforced concrete. However, like all methods of calculation based on the breaking stage, the theory gives no information about the magnitude of the deflections or about the risk of cracking. To get an understanding of these, a special investigation is required.

A problem that has recently been the subject of a good deal of research work is the question of the best and cheapest way of constructing concrete runways for airfields. In most cases, designers have gone in for plain concrete slabs. These plain slabs, however, are often rather thick, and, moreover, the surface must be divided into a large number of squares. If, instead, reinforced slabs are used, the thickness can be reduced and at the same time larger units can be cast. In this way the designer can avoid joints in the surfacing, which from many points of view are a troublesome problem.

The calculations for a concrete pavement of this kind on yielding ground can be a difficult problem. It appears, however, that here, too, the line of fracture method can give good results. The breaking of the slab takes place along certain fixed lines. On the underside of the slab these are straight lines, and on the upper side circles, or curves resembling ellipses.

With the help of a large number of investigations we have succeeded in showing that the breaking load P can be calculated from the equation:

$$m+m'=\frac{P}{2\pi}(1-0\cdot614\sqrt[3]{a^2})$$

$$a=\frac{c}{l}\qquad l=\sqrt[4]{\frac{N}{k}},$$

where

c = the mean radius of the loaded surface.
N = the flexural rigidity of the slab, calculated for stage II.
k = the modulus of foundation of the ground.
m = ultimate positive moment per unit of breadth of slab.
m' = negative moment per unit of breadth of slab.

For the case where the elasticity or bearing property of the ground cannot be defined by a modulus k, but must rather be defined by a modulus of elasticity (semi-infinite body), the formula takes on a different form, but remains in principle the same.

A Levelling Machine

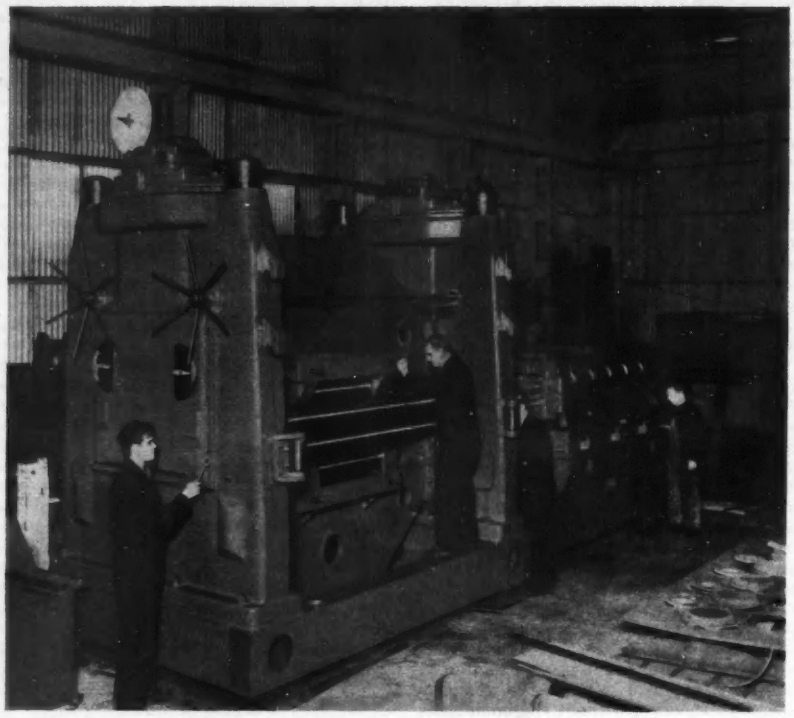
We reproduce overleaf a photograph of an eleven-roll backed-up levelling machine which was recently designed and built by the Bronx Engineering Company, Ltd., of Lye, near Stourbridge, for a steel works in France. This machine is designed to level plates from ¼in to ½in thick made in various widths up to just over 98in.

The machine is driven by a 100 h.p. motor through a flexible coupling to a totally enclosed three-tier cast iron gearbox. All gearing is of special alloy steel forgings cut with double helical teeth, and the gearbox is subdivided into two compartments. One compartment contains the high-speed reduction gears, which are mounted in roller bearings, and the other the slow-speed output driving shafts, one shaft for each of the eleven levelling rolls.

Drive is taken from the gearbox to the eleven rolls, six at the top and five at the bottom by mill type universal couplings and coupling spindle bars. Laminated plastic half-moon bearings in the universal couplings are all individually greased by independent grease nipples. Lubrication of the forty-eight bearings in the gearbox is effected from a large oil gallery round the inside of the top tier. Oil is fed into the gallery by the high-speed gears and is piped down to the individual bearings.

The actual levelling unit consists of two

massive semi-steel split housings mounted on a fabricated steel baseplate. The cast iron box-form bottom support roll bridge extends below the baseplate level and a top support roll bridge of similar construction is bolted to the top roll chock housings. Both the top and the bottom levelling rolls can be preloaded as required by the adjustable support roll blocks, a simple four-point taper wedge providing the means for adjustment.



ELEVEN ROLL LEVELLING MACHINE

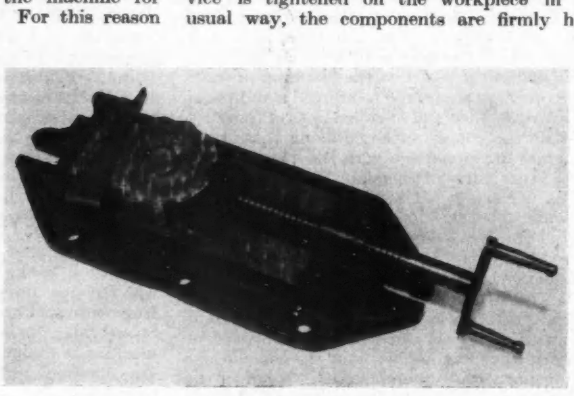
The machine is arranged for reverse levelling, by which, for setting and other purposes, the plate can be reversed by the machine for levelling in either direction. For this reason neither the ingoing nor outgoing top levelling rolls are supported, and they are longer than the supported levelling rolls. Individual adjustment is provided for these two top rolls. The whole bank of top rolls and support bridge is adjustable as a single unit by a separate motor mounted on a fabricated steel bracket bolted to the right-hand frame housing. All the worm and worm wheel gearing of this roll adjustment unit is totally enclosed and runs in oil.

A large dial indicator is fitted to show the position of the top bank of levelling rolls, while individual indicator fingers are arranged to show on a graduated scale the position of the top ingoing and outgoing rolls in relation to the four supported top rolls. By the use of idle inlet and outlet rolls fouling the housings by wide plates is avoided.

Turret Jaw Vices

A RANGE of bench and machine vices which has been introduced by the Blending Machine Company, Ltd., of Bond Street, Hockley, Birmingham, is particularly intended to facilitate the clamping and supporting of components of irregular shape. In each of these vices the sliding jaw is fitted with a turret similar to that shown on the machine vice we illustrate herewith. This turret has cut round its periphery a series of grooves, notches, and vee slots, together with a wide flat face.

When the vice is in use the turret can be set with the flat face opposite the fixed jaw when it is required to hold square-faced components. When components of round or irregular shape have to be gripped, the turret is turned to bring the suitable groove, vee or notch opposite the fixed jaw, and when the vice is tightened on the workpiece in the usual way, the components are firmly held.



TURRET JAW MACHINE VICE

A shallow vee groove is cut in the face of the fixed jaw to facilitate the gripping of these irregular and round components. When it is required to grip tapered or wedge-shaped components the flat face of the turret can be set at an angle.

Machine vices of this kind are made by the firm in three sizes with 3in. 4½in and 6in jaws, and bench vices with 3in, 4½in, 6in and 9in jaws.

EXHIBITION AT GREENOCK.—An exhibition entitled "Greenock Can Make It" was opened at the Town Hall, Greenock, on September 15th. It was arranged to demonstrate the various industries of the neighbourhood and included many examples of local craftsmanship. Exhibits from shipbuilding and marine engineering firms in the vicinity naturally occupied a prominent place in the exhibition.

French Engineering News

(From our French Correspondent)

Some 1200 exhibitors will take part in the Paris motor show, which opens on October 4th. Foreign manufacturers will be represented by twenty American, nineteen English, thirteen German and six Italian concerns and, for the first time, one Spanish firm. Preliminary reports seem to indicate that the Salon will not lack novelty, both with regard to technical and other matters. French manufacturers are making a considerable effort both to introduce new models and to reduce prices.

* * *

Prospecting for oil in the Paris region is continuing, but the engineers concerned have been ordered to give no indication as to whether oil has been found or not. Prospecting is also being carried on in the Pyrenees, where fields at Lacq are producing 20,000 tons monthly.

* * *

Charbonnages de France has published reports on some of its activities in 1950. A temporary fall in consumption at the beginning of the year resulted in the dismissal of some miners but this situation changed rapidly. Nevertheless, in spite of efforts to bring miners back to the pits, production fell in some areas, including the Loire, where 3,585,000 tons were mined, against 3,830,000 tons in 1949. Production per miner increased from 1112kg in 1949 to 1193kg and the cost per ton increased from 3676 francs per ton to 3823 francs. Other areas showed a similar trend. At Cevennes production fell despite an increase in per capita production. The Blanzy coalfield also showed a fall in production. None of the pits made a profit last year.

* * *

The S.N.C.F. is studying a special shock-absorbing chassis for goods wagons used for carrying delicate goods. The chassis is rigidly fixed on to the frame of the truck but its underside is supported on ball bearings and mounted on a fixed structure, to which it is attached by four springs and a brake. The brake serves to steady the upper part resting on the ball bearings. When the truck moves, the chassis on its bearings absorbs about 15 per cent of the shock, whilst the springs absorb about 45 per cent, after which the springs return the chassis to its normal position. A model of the unit has been constructed and experiments are being carried out. If they are satisfactory the shock-absorbing chassis will be introduced on a number of trucks intended for carrying delicate merchandise.

* * *

Reports on the fourth year of the modernisation programme for the steel industry are now appearing. It is stated that the work is proceeding slowly and that in 1950 six crushing and agglomeration installations were completed at Mont-Saint-Martin, Micheville, Thionville, Homécourt, Knutange and Rombas.

Some fifteen blast furnaces were under construction but only two were completed. The other thirteen, however, should be completed some time this year or early in 1952. Out of eighteen Martin furnaces seven of 40 to 45-tons capacity were completed and installed. At Mondeville two 45-ton furnaces were completed and at Senelle a 70-ton furnace came into service. Micheville will soon have a 120-ton furnace in service and Usinor will have completed the modernisation of a 70-ton furnace by the end of this year. Thomas converters have been built or modernised for Longwy, Rehon, Thionville and Denain. Installations are now going ahead for Hyange and Homécourt. Three 23 to 30-ton electric furnaces have been installed at Denain, Hagondange and Creusot, respectively, while smaller furnaces from 2 to 12 tons are being installed in five different steel plants. Installations of rolling mill plant have also made good progress.

It is expected that by 1953 the original plan will be completed. If the modernisation programme runs according to plan it is likely that production potential will be increased from 10 to 12·5 million tons of steel ingots. Sheet production will be doubled and there will also be an improvement in quality.

Industrial and Labour Notes

Steel Supply Prospects

In the latest edition of its *Monthly Statistical Bulletin*, the British Iron and Steel Federation discusses steel supply prospects for the remainder of this year and for 1952. It points out that production of steel ingots and castings in the first six months of this year amounted to 8,153,000 tons, which represents an annual rate of 16,306,000 tons, compared with an annual rate of 16,619,000 tons in the first half of 1950. To achieve an output of 16,000,000 tons in the year 1951, however, the industry needs to maintain an annual rate of 15,700,000 tons over the second half of the year, but it has to take into account, of course, wide fluctuations as a result of holidays. The annual production rate fell to 13,317,000 tons in July, and was 13,855,000 tons in August, compared with 14,530,000 tons in August, 1950.

The Federation goes on to say that steel imports constitute one of the main elements in the supply position. Owing to the pressure of demand abroad, imports of steel in the first half of this year were lower than in the corresponding period of last year, while exports showed only a slight reduction. In the first half of this year, however, it was possible to augment current production of finished steel by drawing upon producers' stocks of ingots and semis, which had been built up to a high level during 1950. As a result home deliveries of steel during the first six months of this year were slightly larger than in the comparable months of 1950. Stocks of ingots and semis, the survey adds, still amount to about 705,000 tons. It is hoped that steel imports for the rest of this year will be appreciably larger than in the second half of 1950, while exports are expected to be sharply reduced as a result of decisions taken by the Government earlier in the year. If these expectations are realised, home deliveries from July to December should be at an annual rate of 14,640,000 ingot tons, compared with 13,860,000 in the second half of last year.

On these assumptions, the Federation observes, the expectation of an increase in steel deliveries to the home market will be realised. But it must not be forgotten that steel consumption in the United Kingdom benefited last year from a substantial draught on consumers' and merchants' stocks. Since these are now at a relatively low level, similar relief cannot be anticipated this year.

The Coal Situation

Coal production in this country is now recovering from the effects of the holiday season, although distributed stocks are very little higher than they were at this time last year, and consumption continues to increase. Moreover, the decline in mining manpower has not yet been arrested.

In the week ended September 15th, output of deep-mined coal amounted to 4,162,000 tons and of opencast, 239,100 tons, giving a total of 4,401,100 tons. In the first thirty-seven weeks of this year total coal production was 155,682,700 tons, compared with 152,029,200 tons in the corresponding period of last year. Inland consumption in the first thirty-six weeks this year, however, took up 142,343,000 tons, as against 136,757,000 tons in the first thirty-six weeks of 1950. On September 8th the total number of workers on colliery books was 696,700, of whom 286,300 were face workers, this latter figure being no higher than that returned for the corresponding date of 1950. Total distributed stocks of coal on September 8th were 14,478,000 tons, compared with 13,715,000 tons on September 9, 1950.

According to the information division of the Treasury, home consumption of coal this year is likely to be about 210,000,000 tons. During the first half of this year the annual rate of production was 5,200,000 tons higher than the average for 1950, but home consumption was 8,400,000 tons higher. The Treasury points out that there are, of course, only two ways of raising coal output; the first being to get more men into the industry and the second to raise the output obtained by each man in it. It is suggested that, in the longer run, there are excellent prospects that the second of those methods will, through the "radical technical transformation" of the industry which is already resulting in rising productivity, supply all the coal needed for internal consumption and exports. Meanwhile, more men are required and, the Treasury says, it is the intractable nature of this problem that calls for the application now of every possible measure, such as the introduction of Italian workers. Such measures, it is believed, will help until technological progress enables the coal mining industry to meet its needs by more normal methods of recruitment.

Coal Miners' Wages

Last week it was stated that the executive of the National Union of Mineworkers had decided to approach the National Coal Board for a minimum wage of £7 10s. a week for underground workers and for an increase of 3s. a shift for piece workers. The present minimum wage for underground workers is £6 7s. It has been suggested that the demand represents a wage increase of about 18 per cent and, if granted, would cost somewhere in the region of £35,000,000 a year. The executive decided also to recommend to a delegate conference of the union the acceptance of a pensions scheme, details of which have been worked out jointly by the union and the Coal Board. It is estimated that the scheme, which provides for the inclusion of all mineworkers between the ages of sixteen and sixty-four, will cost the Board £150,000,000 over the next thirty years.

Manpower on the Railways

The manpower situation on British Railways is dealt with in the current issue of *Bulletin for Industry*, a monthly review of the economic situation, which is prepared by the information division of the Treasury. It is stated that the loss of staff has been most serious in certain essential sections, such as key operatives and footplate grades. Over 3600 signalmen, goods shunters and goods guards left the railways in the year ended March last, a number which represented a 6 per cent loss in those grades. By the end of the summer it is expected that there will be 7 per cent fewer than in March, 1950. In the footplate grades the number employed this March was 5 per cent less than a year earlier. On the civil engineering side of the railways the wastage has been as great, except that here, the bulletin says, numbers have been falling for a longer period. From January, 1948, to March, 1951, the total loss in civil engineering staff was 13,861. If the decline continues, it seems likely that by next March the figure will be in the region of 19,000, or upwards of 23 per cent of the strength in January, 1949. Loss of signalling and telecommunication staff has been equally serious. Taking all grades of railway staff, it is estimated that the number of vacancies which could not be filled this June was approximately 25,000.

Dealing with transport prospects during the coming winter, the bulletin warns that the problem is likely to be more acute as there will be fewer staff and more traffic. Freight to be carried this winter may well be about 3 per cent greater than last, with increased movements of coal, minerals and general merchandise. The increased traffic, in fact, represents a demand of 10,000 wagons more per week than last winter. The expected increase in coal traffic is put at over 3,000,000 tons, a large part of the increase being likely in coal divisions where railway staff difficulties are most pronounced. Already this summer the Railway Executive has had to take the unprecedented step of putting an embargo on the movement of coal trains. The use of wagons to maximum capacity, the correct timing of the flow and loading of traffic to avoid congestion at marshalling yards, and the quicker discharge of wagons are among the suggestions which have been put forward to avoid delay. Furthermore, the railways are planning for a maximum diversion of coal to road transport and to coastal shipping. Cuts in passenger train services have also been planned in order to release railway staff in areas of serious traffic congestion.

British Overseas Trade

The final figures of Britain's overseas trade in August, which were issued at the end of last week by the Board of Trade, show that the value of exports was £226,200,000, which was £4,000,000 more than in July and £6,200,000 above the average for the second quarter of this year. The volume of exports in August was about the same as in July. Re-exports in August were valued at £13,700,000.

The Board of Trade says that exports of manufactured goods in August totalled £200,700,000, a figure £6,800,000 above the average for the second quarter. The value of August exports of metals and engineering products, however, was, at £99,400,000, lower than in July and below the average for the second quarter. This group includes locomotives, ships and aircraft, the August exports of which were valued at £38,100,000, or £2,800,000 less than in July. The number of new cars exported in August was 26,318, compared with 28,872 in July. Exports of refined petroleum in August amounted to 98,000,000 gallons, valued at £3,400,000, a total more than four times the monthly average for 1950.

Imports in August reached a value of £368,500,000, which was 3 per cent above the July level. In the first eight months of this year the value of imports was £2,583,300,000, a sum equivalent to an annual rate 49 per cent above that of 1950. But, the Board of Trade says, in volume the increase compared with 1950 was probably about 15 per cent. The excess of imports (c.i.f.) over total exports and re-exports (f.o.b.) in the first eight months of 1951 was £808,000,000, against £348,000,000 for the whole of 1950.

The index number of import prices in August (1950=100) was, at 138, four points lower than in July, although fairly widespread increases among manufactured goods raised the index for that class alone by four points to 136. The index of export prices (1950=100) rose in August by two points to 124, with the result that the terms of trade as measured by the ratio of import to export prices moved in favour of the United Kingdom, the figure being 111, compared with 116 in July.

Reorganisation of South Wales Steel Companies

The Iron and Steel Corporation of Great Britain has stated that, after a careful examination of the company structure of the steel works operating in South Wales it has decided to reconstitute the boards of Guest Keen and Baldwins Iron and Steel Co., Ltd., and Guest Keen and Nettlefolds (South Wales), Ltd. Guest Keen and Nettlefolds (South Wales), Ltd., was previously a wholly-owned subsidiary of Guest Keen and Nettlefolds, Ltd., and prior to nationalisation it was "hived off" from the parent company. Under the Iron and Steel Act, Guest Keen and Baldwins Iron and Steel Company Ltd., and Guest Keen and Nettlefolds (South Wales), Ltd., passed into public ownership.

In announcing the changes, the Corporation says that in the reorganisation, the management of these companies will become closely associated with that of Richard Thomas and Baldwins, Ltd. The changes, it is claimed, are a logical consequence of the public ownership of the companies and the integration of the steel industry in South Wales.

Notes and Memoranda

Rail and Road

RAILWAY WAGE CLAIM.—At a further discussion of the claims of the Trade Unions at a meeting of the Railway Staff National Council last week, the Council agreed that the claims should be referred to the Railway Staff National Tribunal. All the parties agreed that everything possible should be done to expedite the hearing and that the proceedings before the Tribunal should be in public.

TRANSPORT USERS CONSULTATIVE COMMITTEE FOR YORKSHIRE AREA.—The Minister of Transport has formally appointed the Transport Users Consultative Committee for the Yorkshire Area. The members are: Professor A. N. Shimmin (Chairman), Mr. H. S. Wood, Mr. H. Bradley, Mr. K. Campbell-Cullen, Mr. A. B. Shipley, Mr. W. Cole, Mr. W. Barr, Mr. F. Stott, and Mr. F. Robinson. To represent local authorities there will be on the committee: Councillor H. J. Craven, Alderman H. A. B. Gray, C.B.E., J.P., M.I.Mech.E., M.I.E.E., F.S.S., M.I. Chem.E., Councillor J. Rafferty, Councillor S. I. Dyson, and, representing the British Transport Commission, Mr. E. W. Arkle and Mr. W. M. Hitchcock. The Secretary of the Committee is Mr. J. Horsfield, Commercial Superintendent's Office, North Eastern Region, Railway Executive, York.

THE SPEED OF TRAINS ON CURVES.—In view of the differences in practice which existed among the former railway companies in regard to the limiting values for super-elevation or cant of the track, rate of gain of cant, cant gradient, cant deficiency and rate of gain of cant deficiency on curves, the Railway Executive has been carrying out tests, initiated in 1949, to determine the limiting values for these factors consistent with the comfort of passengers. These tests also covered the phenomena of derailment at low speed on curves of considerable cant, and the redistribution of weight on wagon wheels due to twist, which also contributes to the risk of derailment. As the result of the tests which have now been concluded, limiting values for the factors mentioned have been laid down for general use on British Railways, but wherever circumstances allow the actual values adopted in any case will be well inside those limits. Curves designed in accordance with the new rules will ensure the maximum of safety and riding comfort for passengers.

MAIN LINE DIESEL-ELECTRIC LOCOMOTIVES IN AUSTRALIA.—Last month, the first of ten 1760 h.p. main line diesel-electric locomotives built for the South Australian Government Railways completed its trial runs, and it was placed in regular service on September 10th. This is the first main line diesel-electric locomotive to operate on regular schedules on the mainland of Australia. The motive power equipment including the diesel engine, generator, traction motors and control gear, for the ten locomotives was supplied by the English Electric Company, Ltd., and the new locomotives themselves are being built in the workshops of the South Australian Government Railways. They will be used in pairs to haul the Overland Limited Express, and 600-ton freight trains over the Mount Lofty Ranges, where the ruling gradient is 1 in 40. These double-bogie locomotives have the A1A–A1A wheel arrangement, the outer axles being motored in each three axle bogie, and are equipped with rheostatic braking. Each locomotive has a maximum starting tractive effort of 60,000 lb, a continuous tractive effort of 34,000 lb at 15 m.p.h., and a maximum service speed of 70 m.p.h.

BULK CONVEYANCE OF CEMENT.—Several months ago the possibility arose of conveying, on the North-Eastern Region of British Railways, 40,000 tons of cement in bulk from the Ferriby works of G. and T. Earle, Ltd., Hull, for use in the construction of a new reservoir for the Wakefield Corporation at Baitings, near Sowerby Bridge, in the West Riding. As it was obvious that bulk conveyance would achieve considerable economies, experiments were made with the use of containers to convey this traffic. Although an improved design of standard bulk container is in production for general use throughout British Railways, it was decided that until these standard units became available (early in 1952) it would be feasible to use a cylindrical container, a number of which are at present on hire to British Railways from the Ministry of Supply. This type of container was designed for use during the war for the conveyance of magnesium oxide, and subsequent experiments have shown that it is particularly suited to the conveyance of cement. Each unit is 8ft high and 6ft 6½in in diameter. There is a circular opening at the top for filling, covered by a screw-down weatherproof cover. The inside of the container tapers towards the bottom to a circular discharge outlet controlled by a hinged door equipped with simple hand-operated mechanism. The outside of the unit is sheer, giving a circular base the full diameter of the cylinder with an opening through which the bottom door control mechanism is operated. The tare weight of each unit is 15 cwt and the capacity 160 cubic feet, and although it would be possible to accommodate almost 6 tons of cement, the load has had necessarily to be restricted to 5¼ tons. Four lifting lugs are welded to the top edge so that transfer from wagon to motor is a simple and quick operation. Two of these containers are carried in a standard 13-ton wagon.

Miscellanea

THE SMITHFIELD SHOW.—The Smithfield Show and Agricultural Machinery Exhibition will be held at Earls Court, London, from December 3rd to 7th. The organisers are the Smithfield Show Joint Committee, 148, Piccadilly, London, W.1.

THE BEAMA DINNER.—The next annual dinner of the British Electrical and Allied Manufacturers' Association will take place at Grosvenor House, Park Lane, London, W.1, on Thursday, January 24, 1952, instead of on November 15, 1951, as previously announced.

CITY AND GUILDS OF LONDON INSTITUTE.—It is announced that the Duke of Edinburgh, K.G., F.R.S., has graciously accepted the office of president of the City and Guilds of London Institute for the Advancement of Technical Education, to which he was duly elected at a special general meeting of the members of the Institute on September 21, 1951.

BRITISH ENGINEERS' ASSOCIATION.—The Council of the British Engineers' Association has elected as president for the year 1951/52, Mr. David D. Walker, M.I.E.E., who is joint managing director of Evershed and Vignoles, Ltd., chairman and managing director of Thomas Walker and Son, Ltd., and a director of J. B. Brooks and Co., Ltd. He is also a member of the council of the British Electrical and Allied Manufacturers' Association. Mr. H. S. Broom, M.I.Mech.E., joint managing director of Broom and Wade, Ltd., and a director of B.E.N. Patents, Ltd., has been re-elected vice-president.

CONGRESS ON PRESTRESSED CONCRETE AT GHENT.—In commemoration of their seventy-fifth anniversary, the Association des Ingénieurs Sortis des Ecoles Speciales de Gand recently organised celebrations which included two technical congresses—one on the textile industry and the other on prestressed concrete. The prestressed concrete congress was attended by a number of British engineers, under the auspices of the Prestressed Concrete Development Group of the Cement and Concrete Association. An inaugural address was delivered by Professor Magnel, and there were several technical sessions and visits to prestressed concrete structures.

INCORPORATED PLANT ENGINEERS.—The Scottish branches of the Institution of Incorporated Plant Engineers are arranging a conference, which will be held at Dunblane Hotel Hydro, Perthshire, from Friday afternoon, October 5th, to Sunday, October 7th. At the Saturday morning session the conference will be addressed by Mr. D. Lacy-Hulbert, A.R.I.C., M.Inst.F., president of the Institution, and by Mr. J. F. Field, M.I.Mech.E., controller of the S.E. Scotland Division, British Electricity Authority. On Sunday morning, Mr. L. G. Northcroft, M.I.Mech.E., will speak on "Coal and Europe." The programme also includes coach tours and other social functions.

DETONATORS IN COAL MINES.—The Explosives in Coal Mines Order is being revised as recommended by the recent departmental committee on safety in the use of explosives in coal mines. The new order, it is believed, will provide that detonator cases must be so constructed and maintained that when the case is closed no detonator or lead inside it can touch any metal exposed outside the case. As the departmental committee also made some other recommendations concerning the design of detonator cases, the production department of the National Coal Board has prepared an explanatory memorandum setting out the general principles of the design of detonator cases. The memorandum suggests that detonator cases should be made of strong material, such as tin plate, leather, moulded rubber or wood; they should be self-locking and provided with a key; the interior should be covered with insulating material and partitions should be fitted so that each detonator is contained in a separate compartment.

TIN-NICKEL ELECTROPLATE.—The recently introduced tin-nickel electroplate is said to remain permanently bright when exposed to the atmosphere or to many liquids and sprays that corrode other metals. The resistance of this form of plating to corrosion is such that it can be classed not simply as a decorative plating, but as a material of construction in chemical engineering plant. A book entitled "Electro-deposited Tin-Nickel Alloy Coatings," recently issued by the Tin Research Institute, describes work done in the Institute's laboratories during the past two years. This book first describes the method of the electrodeposition process and shows that the operating conditions are sufficiently flexible to ensure good sound deposits in actual workshop practice. Its second part, dealing with the corrosion tests, puts forward an explanation of the remarkable corrosion resistance of the alloy, which could not be predicted from a knowledge only of the corrosion resistance of tin and nickel separately. Copies of this booklet are available, free of charge, from the Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex, England.

Personal and Business

MR. D. C. JEFFREY has joined the board of Leadbeater and Scott, Ltd., National Steel Works, Sheffield, and has been appointed chairman of the company.

RUSTON-BUCYRUS, Ltd., announces the retirement of Lt.-Col. P. D. Ionides from its Board of Directors on September 30, 1951, and the appointment of Mr. J. C. P. Brunyate, from October 1, 1951.

MR. G. DANIEL, C.B.E., Chief Ship Surveyor of the Ministry of Transport, is retiring at his own request on November 30, 1951, and is being succeeded by Mr. H. E. Steel, Deputy Chief Ship Surveyor.

THE INSTITUTION OF ENGINEERING DRAUGHTSMEN AND DESIGNERS has appointed Mr. L. Bruce Archer, A.M.I.E.D., to the office of honorary proctor. Mr. Archer succeeds Mr. R. R. Osborne, M.I.E.D., M.I.B.C.H.

NORTHERN ALUMINIUM COMPANY, Ltd., announces that from October 1st next the address of their head office and London area sales office will be Bush House, Aldwych, London, W.C.2 (telephone number, Temple Bar 8430; telegrams, "Noraluco, Estrand, London").

ACCORDING to a statement by Mr. Ivan A. R. Stedeford, chairman of Tube Investments, Ltd., agreement has been reached, subject to the completion of legal arrangements, for the acquisition by Tube Investments, Ltd., of the New Conveyor Company, Ltd., of Smethwick.

MR. C. R. AINLEY, who has been with Brush Electrical Engineering Company, Ltd., as a designer-draughtsman, has taken up an appointment with Crypton Equipment, Ltd., Bridgwater (one of the Lancashire Dynamo companies), where he will act as a development engineer for the Foster Switchgear Division now situated at Bridgwater.

DR. E. C. ROLLASON, M.Sc., Ph.D., F.I.M., formerly a delegate director and research manager of Murex Welding Processes, Ltd., of Waltham Cross, Herts, is to take up his appointment to the Henry Bell Wortley Chair of Metallurgy at Liverpool University on October 1st next. He is to be succeeded as research manager by Dr. W. I. Pumphrey, M.Sc., Ph.D., F.R.S.A.

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., announces that, following the recent retirement of Mr. S. Stansbridge, Mr. J. T. Marler has been appointed manager of the company's operating division. Mr. Marler joined the company's staff at the Dalston works in 1907 and in 1930 he was appointed chief of the operating section and in 1947 he became assistant service manager, operating and traffic.

THE POWER-GAS CORPORATION, Ltd., announces that the managing director and vice-chairman, Dr. N. E. Rambush, D.Sc. (Hon.), M.I.Chem.E., has been elected chairman of the company on the retirement of Mr. Wilfred Beswick, who had been chairman of the Corporation since 1939. Dr. Rambush joined the Power-Gas Corporation, Ltd., in 1918 as chief engineer. Nine years later he became technical manager, and in 1931 was appointed general manager to the Power-Gas group of companies. He became a director of Ashmore, Benson, Pease and Co., Ltd., in 1933, and in 1939 was appointed managing director of the Power-Gas Corporation and its subsidiaries, having been joint managing director with Mr. Beswick during the preceding year.

British Patent Specifications

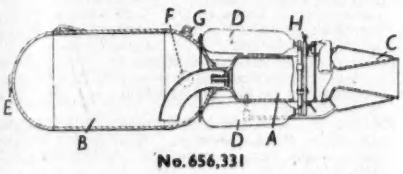
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

AERONAUTICAL ENGINEERING

656,331. January 3, 1949.—Rocket Type Propulsion Apparatus, The de Havilland Engine Company, Ltd., Stonegrove, Edgware, Middlesex, Frank Bernard Halford, of the company, and Arthur Valentine Cleaver, of 47, Parkside Drive, Edgware, Middlesex.

As shown diagrammatically in the drawing, the rocket unit consists of a reaction chamber *A*, into which can be injected a main propellent, for instance, hydrogen peroxide, from a reservoir *B*, and a dissociation catalyst, for instance, sodium or calcium permanganate, from a reservoir *C*. The liquids are injected by compressed gas, which is stored in bottles *D*. The arrangement, construction and operation of the valves shown do not



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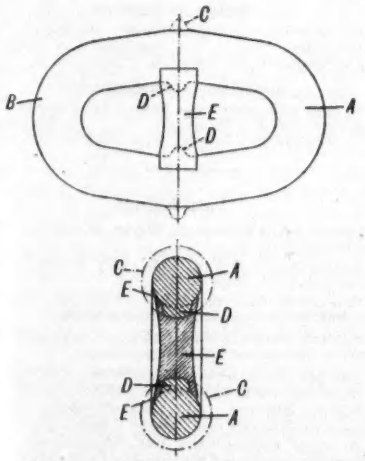
primarily concern the present invention, but if desired they may be as described in Specifications Nos. 656,333, 656,334 and 656335. A suitable propellent injector valve is also described in Specification No. 656,332. For the purpose of mounting the unit on the aircraft three bosses or trunnions are provided, one *E* at the forward end of the hydrogen peroxide reservoir and the others *F* on opposite sides of this reservoir near its rear end. When the unit is loaded the centre of gravity preferably lies within the triangle defined by these three bosses. The thrust is preferably taken by the two side bosses. For handling the unit when it is removed from the aircraft, slinging points *G* and *H* are provided. The centre of gravity of the unit when empty lies between these slinging points. *August* 15, 1951.

MISCELLANEOUS

656,639. February 7, 1949.—The Manufacture of Studded Chain Links, Humphrey George Taylor, "Ridgway," Lower Penn, near Wolverhampton.

Referring to the drawings, the link is first formed, without the stud, from two C-shaped end loops *A* and *B*, by butting their inner ends together and joining them by flash welding. The squeezing pressure on the ends of the loops during the welding process causes an annular rib to be



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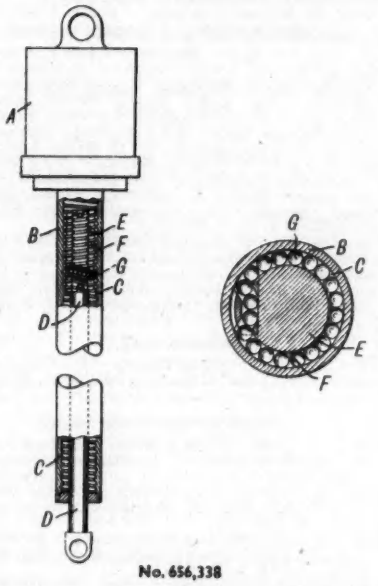
formed on each side member of the link, as indicated by chain lines at *C*. Each flash is then chipped or ground off except for a portion *D* projecting inwards and having an arcuate shape, well within the thickness of the link, and a tapered cross section. To cast a stud into each link it is laid out on a bed and chill moulds, formed in halves, are temporarily fitted in the alternate links, which lie flat. Molten iron is poured into the moulds to cast a stud *E* centrally across each link, the metal at the ends of each mould flowing around the two projecting portions *D*. The chain is then turned through 90 degrees about its longitudinal axis and the casting process repeated on the alternate links. The side surfaces of the studs may be slightly hollowed and the ends of each stud turned in, as indicated at *E*, to avoid a narrow taper where it meets the link side. Each stud is completely within the confines of the link.—*August* 29, 1951.

656,338. January 4, 1949.—Screw and Nut Mechanism, General Motors Corporation, of Grand Boulevard, Detroit, U.S.A. (*assignees of Charles H. Mort and Clyde W. Mapes, of* 2808, *E. Fourth Street, Dayton, Ohio, and R.R. No.* 3, *Brookville, Ohio, U.S.A.*).

This invention relates to improvements in screw and nut mechanism in which anti-friction balls are used mechanically to connect the screw and nut. The left-hand drawing illustrates the invention applied to an electric motor driven power device in which the electric motor *A* rotates the elongated tubular nut member *B*, which has a continuous helical groove *C* throughout its entire length. In this application, the screw shaft *D* is the non-rotatable element of the combination, having a forked end adapted to be attached to any member to be moved by the mechanism. The shaft *D* has



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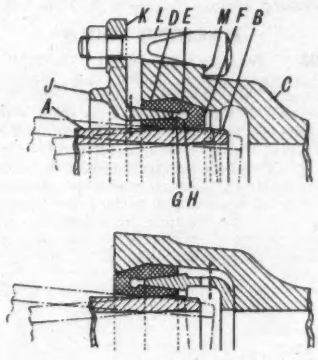
a head portion *E* of enlarged diameter so as to fit slidably within the nut *B*, the outer peripheral surface of this head portion having a helical groove *F* of a size and pitch identical with the helical groove in the nut. The coinciding grooves of the nut and shaft form a helical channel substantially circular in cross section. In order mechanically to connect the nut and shaft, so that rotation of the one will cause the other non-rotating member to move axially, anti-friction balls *G* are inserted in the helical channel. To assure circulation of the anti-friction balls and prevent their passing out of the helical channel as one element is rotated relatively to the other, the helical channel cannot consist of continuous helical convolutions, but must consist of one or more closed circuit convolutions in which the balls circulate around and around. —*August* 22, 1951.

TUBE AND PIPE COUPLINGS

656,984. January 22, 1949.—Flexible Pipe-Joints, Harry Noblet, 18, Fernbrook Drive, North Harrow, Middlesex.

The joints described are particularly for spigot and socket pipes of the centrifugally spun or vertically cast type, for use in water, gas or other subterranean mains. The upper drawing shows an elevation in section of a flexible joint, for joining the spigot-end of one pipe to the internally tapered socket-end of an adjoining pipe by the use of a separate external pressure-ring of annular wedge-shaped section and a preformed flexible packing-ring bifurcated in the direction of its axis. The spigot-end of pipe *A* is made with a slightly tapered end *B*, which is inserted during assembly into the tapered socket-end of an adjoining pipe *C*. The socket-end of this pipe is formed with the tapered surfaces *D* and *E*, comprising a shallow annular groove around the interior of the socket-end, so that the angle of the tapered surface *E* is more pronounced than the angle of the surface *D* relative to the axis of pipe, these surfaces being tapered in opposite directions. A preformed flexible packing-ring *F* of moulded rubber or other suitable resilient material, is bifurcated by a deep annular tapered groove *G*, which has at its root an enlarged annular space *H*, which acts as a pneumatic cushion. The flexible ring also has an inner convex surface, which in contact with the outer surface of pipe *A* allows for



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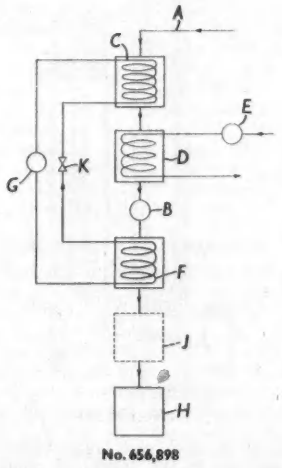
a prescribed degree of angular displacement between the axes of pipes *A* and *C*, as indicated by chain-dot lines. The preformed flexible packing-ring is inserted into the internally tapered socket-end of pipe *C*, as shown. A separate externally flanged pressure-ring *J* of wedge section, is assembled over the tapered spigot-end of pipe *A*, which is inserted through the preformed flexible packing-ring. External pressure is applied to the pressure-ring by lugs *K* and hook-bolts *L*. By tightening the hook-bolts a fluid-tight joint is formed between the flexible packing-ring and the two pipes. According to a modified form of the invention as illustrated in the lower view, there is an internal pressure-ring of annular wedge-shape section, and the bifurcated packing-ring is reversed as shown.—*September* 5, 1951.

AGRICULTURAL ENGINEERING

656,898. April 6, 1949.—Methods and Means for Drying, Agricultural and Industrial Dryers, Ltd., Granite House, Cannon Street, London, E.C.4 (*Inventor: Alfred Gordon Evans Robiette*).

The invention concerns apparatus for producing warm, dry air for such purposes as the drying of grass, grain and other animal feeding-stuffs. As shown in the accompanying diagrammatic drawing, air is drawn into a pipe *A* by a fan *B* and passed through the expansion coil *C* of a refrigerating system, where the air is cooled to a temperature of, say, 2 deg. Cent., sufficient to remove the greater part of its moisture content. From the coil of the refrigerator the air passes to a heat exchanger *D*, in which it is brought up to approximately atmospheric temperature by heat exchange



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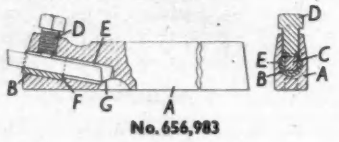
with atmospheric air from a second fan *E*. The air passed into the heat exchanger by the fan is independent of the air to be warmed and dried. The air thus dried and at room temperature then passes through the compression coil *F* of the same expansion and compression refrigerating system. From the heat exchanger the dried air is passed over the condenser coil *F* on the compression side of the refrigerating cycle, where it is

raised to a temperature of, say, 40 deg. Cent' From the condenser coil the dried and heated air may be passed directly to a drying oven or kiln *H*, or it may be passed into an auxiliary heater such as the electric resistance heater shown at *J*, whence it passes to the oven or kiln. Alternatively the air may be further heated by passage over the radiator and exhaust of an internal combustion engine, used to drive both the fans and the compressor. *K* is the usual expansion valve of the refrigerating cycle.—*September* 5, 1951.

MACHINE TOOLS

656,983. January 22, 1949.—CUTTING TOOL HOLDERS, Ralph Miller and Ernest Penn, both of 5, Caroline Street, Birmingham, 3.

The tool holder comprises a steel shank *A*, having in the forward end a circular hole inclined to the axis. In the hole is inserted a tightly fitting bush *B*, of hardened steel, having a rectangular groove cut along its length to take a square cutting tool. The tool is secured in the bush by a screw *D* inserted laterally through the holder and the open side of the groove. Preferably at the rear end of the hole there is another hole *E* of rather smaller



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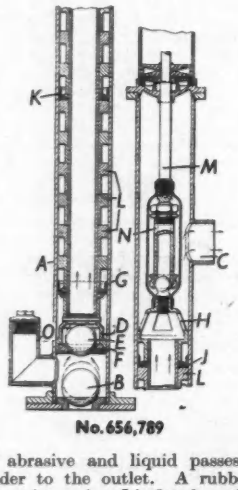
diameter and of sufficient length to receive the inner end of the tool when it extends beyond the bush. The second hole is arranged eccentrically to the first hole so that its upper side is continuous with the upper side of the first hole, leaving a step or shoulder *F*, which provides an abutment for the inner end of the bush. For convenience in draining the hole and removing the chippings produced by the tool, an opening *G* is provided. By this invention it is claimed that the necessary accuracy of form of the part which supports the tool is easily assured, and the support given to the tool is such as to obviate risk of straining, distortion or breaking when tightened in position and in use, or chatter of the tool when in use.—*September* 5, 1951.

PUMPS

656,789. April 5, 1949.—RECIPROCATING PUMPS, Norman Ives Ashworth, 195, Loxley Road, Stratford-on-Avon.

The pump, for liquids carrying abrasives, comprises a vertical cylinder *A* having a non-return ball valve *B* at the foot and an outlet *C* in the cylinder near the upper end. The plunger of the pump is tubular and the lower end is fitted with a cage *D*, in which a large ball *E* is located to co-act with a valve seating *F* on the bottom of the cage. When the ball is seated the bottom of the hollow plunger is closed. A suction cup washer or piston ring *G* of rubber fitted on the plunger a short distance above the cage, forms a liquid-tight piston ring. Perforations *H* are provided in the hollow plunger at the delivery end through which the



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mixture of abrasive and liquid passes into the pump cylinder to the outlet. A rubber suction cup washer or piston ring *J* is fitted on the plunger below the outlets *H* and a similar washer or ring *K* is fitted on the plunger in an intermediate position between the cup washers *J* and *G*. Cast iron piston rings or collars *L* are arranged on the plunger between the cup washers, a portion of the collars being reduced in diameter to form annular grooves. The collars and each end of the plunger has a free sliding fit on the wall of the pump cylinder. The plunger is reciprocated by a double acting air motor, the piston rod *M* of which is coupled to the plunger by means of a union tube *N* enclosed in a rubber casing tube. The cup washers prevent leakage between the plunger and the wall of the cylinder, but should any leakage take place past the washers, the liquid is accommodated in the grooves. A priming tube *O* is provided at the base of the pump cylinder. On the upward stroke of the pump the liquid material is sucked into the base of the cylinder through the non-return ball valve and at the same time any liquid in the pump cylinder above the piston is lifted and discharged through the outlet opening. On the down stroke of the plunger, the ball valve at the foot of the cylinder is closed and the ball valve at the foot of the hollow plunger is opened and the liquid passes up the hollow plunger and through the perforations into the pump cylinder above the plunger.—*September* 5, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Mon., Oct. 1st.—LEEDS BRANCH: E.L.M.A. Lighting Service Bureau, Leeds, "Research on Lamps and Lighting," R. V. Mills, 7.30 p.m.——N.E. LONDON BRANCH: Angel Hotel, Ilford, "Modern Installations," W. F. Parker, 8 p.m.——SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, "Television Lecture and Démonstration," C. O. Birtles, 7.30 p.m.

Tues., Oct. 2nd.—NEWCASTLE BRANCH: Tyne Hotel, Hood Street, Newcastle, "Wheels Behind the Wheels" 7.30 p.m.——W. LONDON BRANCH: Windsor Castle Hotel, Hammersmith, "Automatic Power Factor Correction," J. Orr, 7.30 p.m.

Wed., Oct. 3rd.—N. LONDON BRANCH: Three Jolly Butchers Hotel, Wood Green, N.22, "Measurement and Quantities," W. H. Brooks, 8.15 p.m.

Thurs., Oct. 4th.—S. LONDON BRANCH: Cafe Royal, North End, Croydon, "Gyroscopes," W. J. Spencer, 8 p.m.

Engineers' Guild

Thurs., Oct. 4th.—YORKSHIRE BRANCH: Hotel Metropole, Leeds, Annual General Meeting, speaker H. Nimmo. 7 p.m.

Illuminating Engineering Society

To-day, Sept. 28th.—LEEDS CENTRE: Guildford Hotel, The Headrow, Leeds, 1, Chairman's Address, J. Sewell, 7 p.m.

Mon., Oct. 1st.—SHEFFIELD CENTRE: The University, Western Bank, Sheffield, Chairman's Address, G. L. Tomlinson, 6.30 p.m.

Tues., Oct. 2nd.—STOKE-ON-TRENT GROUP: 31, Kingsway, Stoke-on-Trent, "Lighting of the Houses of Parliament," R. L. C. Tate, 6 p.m.

Wed., Oct. 3rd.—NEWCASTLE CENTRE: Minor Durrant Hall, Oxford Street, Newcastle upon Tyne, 1, Chairman's Address, W. H. Dodgson, 6.15 p.m.

Thurs., Oct. 4th.—LEICESTER CENTRE: E. Midlands Electricity Board, Charles Street, Leicester, "The Lighting of the New House of Commons," 6.30 p.m.——EXETER GROUP: Providence Hall, Northernhay Street, Exeter, "Stage Lighting," J. W. Strange, 7 p.m.

Fri., Oct. 5th.—BATH AND BRISTOL CENTRE: S.W. Electricity Board, Old Bridge, Bath, "Stage Lighting," J. W. Strange, 7 p.m.——HUDDERSFIELD GROUP: Electricity Showroom, Market Street, Huddersfield, "Lighting for High Speed Photography and Cinematography," J. Hadland, 7.15 p.m.

Incorporated Plant Engineers

To-day, Sept. 28th.—BIRMINGHAM BRANCH: Imperial Hotel, Birmingham, Symposium of Films on "Welding," 7.30 p.m.

Institute of British Foundrymen

Mon., Oct. 1st.—SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, "The Training of Foundry Technicians," W. J. Colton, 7.30 p.m.

Wed., Oct. 3rd.—N.E. SCOTTISH SECTION: Imperial Hotel, Keptie Street, Arbroath, "Cast Iron as an Engineering Material," H. T. Angus, 7.30 p.m.

Institute of Marine Engineers

Tues., Oct. 2nd.—85, Minories, London, E.C.3, Presidential Address, S. F. Dorey, F.R.S., 5.30 p.m.

Institute of Navigation

Fri., Oct. 19th.—Royal Geographical Society, 1, Kensington Gore, S.W.7, Presidential Address, "Navigation and the Shipping Industry," Sir Robert Watson-Watt, 3 p.m.

Institute of Petroleum

Wed., Oct. 3rd.—26, Portland Place, London, W.1, "The Training of a Technologist," 5.30 p.m.

Institute of Road Transport Engineers

Wed., Oct. 3rd.—Central Hall, Broadway, Westminster, London, S.W.1, Annual General Meeting, followed by Extraordinary General Meeting, 6.30 p.m.

Institution of Incorporated Plant Engineers

Fri. to Sun., Oct. 5th to 7th.—Hotel Hydro, Dunblane Perthshire, Scottish Conference.

Institution of Mechanical Engineers

Thurs., Oct. 4th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Industrial Design and its Relation to Machine Design," H. G. Conway, 6.45 p.m.

Fri., Oct. 5th.—N.E. BRANCH, GRADUATES' SECTION: Northern Gas Board Showrooms, Grainger Street, Newcastle upon Tyne, "Materials Testing," M. Milne, 7 p.m.——SOUTHERN BRANCH, GRADUATES' SECTION: Municipal College, Brighton, Chairman's Address, R. P. Scott, 7 p.m.

Institution of Post Office Electrical Engineers

Tues., Oct. 2nd.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, "Transmission Performance of the Telephone Network—A Survey of Some Basic Problems," J. Swaffield and D. L. Richards, 5 p.m.

Institution of Production Engineers

Mon., Oct. 1st.—WESTERN SECTION: Grand Hotel, Bristol, Formation of Graduate Section, 7.15 p.m.

Tues., Oct. 2nd.—READING SECTION: Great Western Hotel, Reading, "Industrial Incentives," R. N. Marland. 7.15 p.m.

Wed., Oct. 3rd.—NOTTINGHAM SECTION: Victoria Station Hotel, Nottingham, "The Fatigue of Metals," J. A. Pope, 7 p.m.——SOUTH ESSEX SECTION: S.E. Essex Technical College, Barking, "The Problems of Modern Management," Lewis C. Ord, 7.30 p.m.——DUNDEE SECTION: Imperial Hotel, Arbroath, "Cast Iron as an Engineering Material," H. T. Angus, 7.30 p.m.

Thurs., Oct. 4th.—LONDON SECTION: Royal Empire Society, Northumberland Avenue, W.C.2, "Increased Productivity by the Use of Compressed Air," N. P. Watts, 7 p.m.

Fri., Oct. 5th.—WEST WALES SECTION: Central Library, Alexandra Road, Swansea, "History and Development of the Tube Industry," W. Goldsworthy, 7.30 p.m.

Institution of Sanitary Engineers

Wed., Oct. 3rd.—Caxton Hall, Westminster, S.W.1, "Concrete Lining of Corroded Water Mains," R. Petherbridge, 6 p.m.

Liverpool Engineering Society

Wed., Oct. 3rd.—24, Dale Street, Liverpool, Presidential Address, E. Walker Elliott, 6 p.m.

Liverpool Joint Chemistry Committee

Thurs., Oct. 4th.—The University, Liverpool, "Publicity for Chemistry," B. D. W. Luff, 7 p.m.

Manchester Geological and Mining Society

Thurs., Oct. 4th.—Mining and Technical College, Library Street, Wigan, Annual General Meeting and Presidential Address.

North-Western Fuel Luncheon Club

Wed., Oct. 3rd.—Engineers' Club, Albert Square, Manchester, Annual General Meeting, "Planned Co-operation or Chaos," R. Alan S. Thwaites, 1.30 p.m.

Royal Aeronautical Society

***Thurs., Oct. 4th.*—Institution of Civil Engineers, Great George Street, S.W.1, Seventh British Commonwealth and Empire Lecture, "Air Transport in New Zealand and the South Pacific," Air Vice-Marshal Sir L. M. Isitt, R.N.Z.A.F., 6 p.m.**

Sheffield Metallurgical Association

Tues., Oct. 2nd.—Grand Hotel, Sheffie d, "World Survey of the Iron and Steel Industry," R. A. Hacking, 6.15 p.m.

Society of Engineers

Mon., Oct. 1st.—Geological Society, Burlington House, Piccadilly, W.1, "The Application of Electronic Instruments to Industry," S. F. Smith, 5.30 p.m.

Stephenson Locomotive Society

Sat., Sept. 29th.—MIDLAND AREA: 71, Edmund Street, Birmingham, "Symphony No. 5, Unfinished," (L.M.S. Standard 4–6–0s), W. H. Whitworth, 7 p.m.

Catalogues

GANDY, Ltd., Wheatland Works, Wallasey.—Belting Products Catalogue.

SIMPLIFIX COUPLINGS, Ltd., 157, Victoria Street, London, S.W.1. Price List.

VICKERS-ARMSTRONGS, Ltd., Weybridge, Surrey.—Illustrated catalogue of aircraft accessories.

HOLMAN BROS., Ltd., Camborne.—Illustrated catalogue of drifters, for wet or dry drilling.

GIBBONS BROS., Ltd., Dibdale Works, Dudley, Worcs.—Booklet illustrating principal plants built since 1945.

B.E.N. PATENTS, Ltd., High Wycombe, Bucks.—Catalogue CB.94, entitled "Spray Painting Equipment."

SHARPLES CENTRIFUGES, Ltd., Woodchester, Stroud, Gloucester.—Bulletin 551, dealing with super-centrifuges.

HYLAND, Ltd., Doncaster Road, Wakefield.—Leaflet illustrating and describing hand-hydraulic steering gears.

MONO PUMPS, Ltd., Mono House, 67, Clerkenwell Road, London, E.C.1.—Leaflet dealing with automatic water pressure system for ship's fresh water and sanitary supplies.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., St. Paul's Corner, 1–3, St. Paul's Churchyard, London, E.C.4.—Folder giving details of a new range of fluorescent fittings.